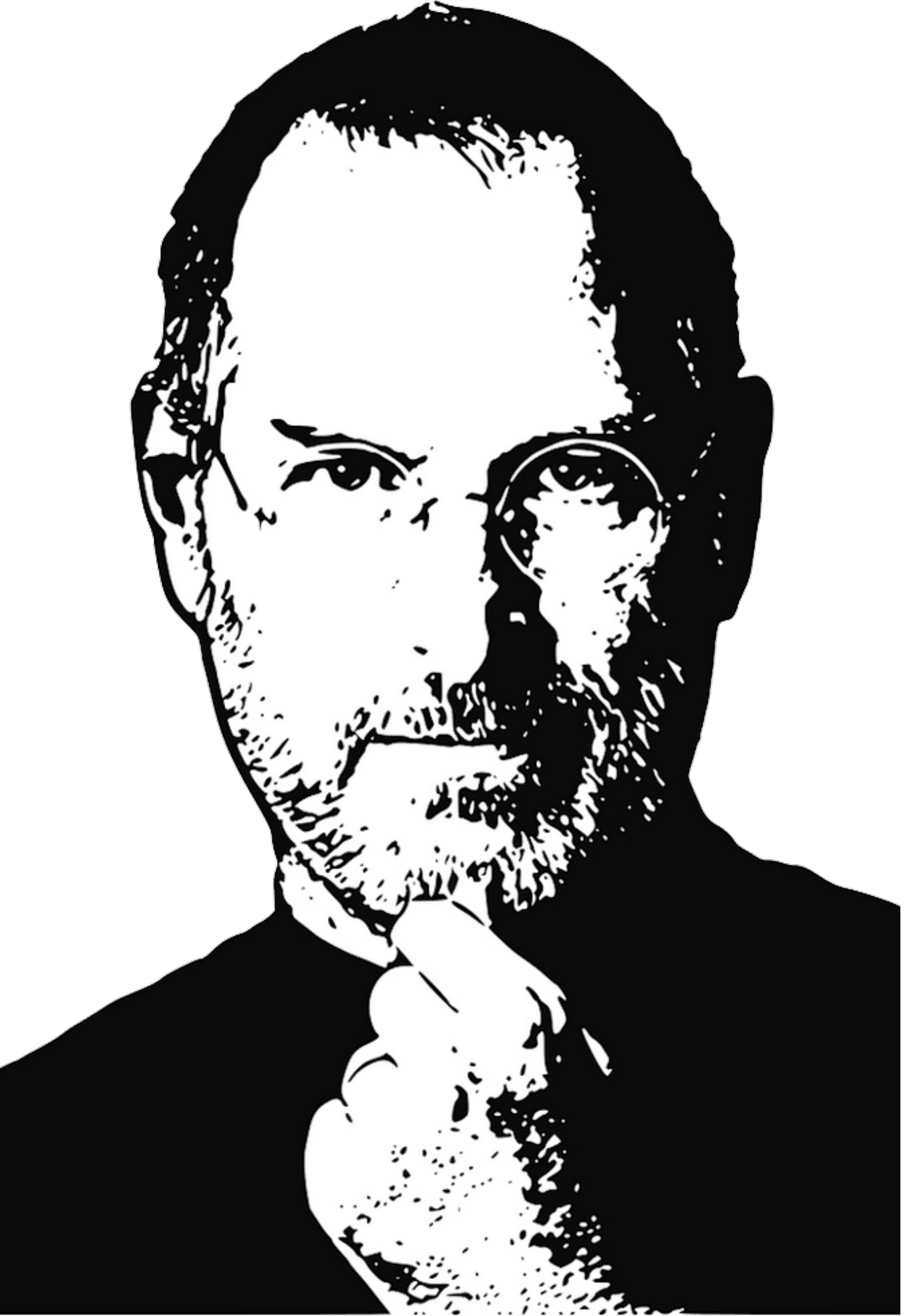
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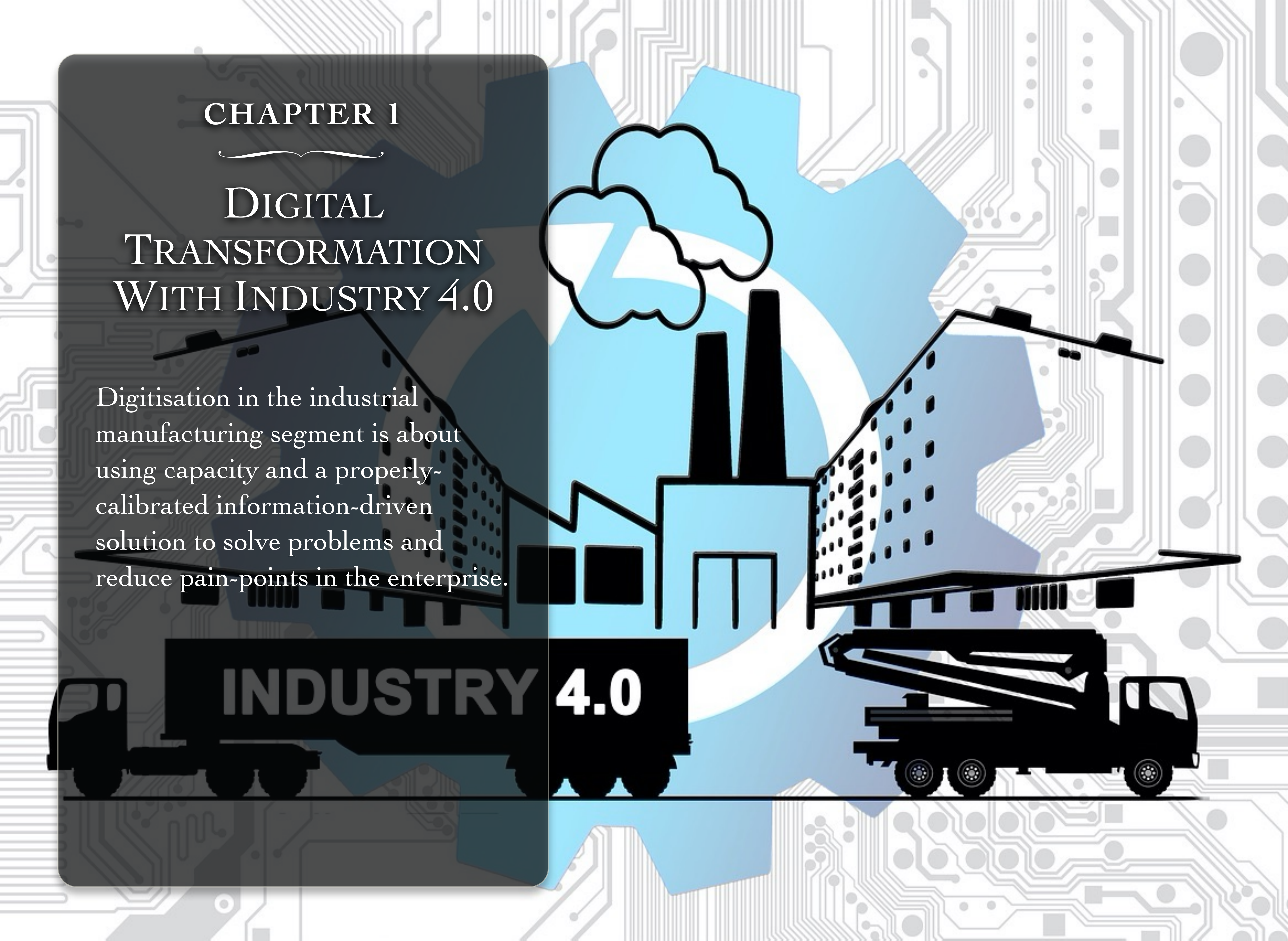
“STAY HUNGRY, STAY FOOLISH” - STEVE JOBS


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Service
INDUSTRY 4.0

CHAPTER 1

Digital Transformation With Industry 4.0

Digitisation in the industrial manufacturing segment is about using capacity and a properly-calibrated information-driven solution to solve problems and reduce pain-points in the enterprise.



Digital Transformation With Industry 4.0

- By Deepshikha Shukla

Digital transformation only makes sense if it supports an organisation's overall strategy. Smart models of manufacturing and business are being created through collaborative and self-aware machines and processes. This has a direct impact on competitiveness and the quality of goods and services.

In the era of smart manufacturing, human beings and machines will be linked together by data networks. However, networking within production processes and across company boundaries is possible only if standards and specifications are in place that are applicable throughout the world. Self-driven businesses is the way forward for the Indian manufacturing ecosystem, and it is achievable in a manner that works for all.

Smart manufacturing began for promoting efficiency in the commercial sector, but now its potential for public benefit is increasingly being recognised. On the other hand, smart infrastructure is leading the way to a new set of economies around data gathering, decision-making and public utility technology. As world digitisation progresses, different infrastructures will have to compete with each other to achieve the fastest economic growth. The winner of this race will be the infrastructure that manages complexity of its size best. In other words, infrastructure will need to become smart to maintain its competitive advantage.

The manufacturing industry is being reshaped by the fourth industrial revolution, powered by the Internet of Things (IoT). This IoT revolution will help upgrade factories or build new systems from scratch to increase productivity and stakeholder value profoundly. Through integration of several modern technological innovations, such as advanced process control and smart panels, the concept of smart infrastructure can witness a massive overhaul in just a short period.

Opportunities for OEMs and their supply chain



Technologies to create breakthrough in digital transformation (Credit: https://colaninfotech.com)

Original equipment manufacturers (OEMs) can leverage augmented reality (AR) for improving workforce productivity. AR enhances users' view of the physical world with the overlay of real-world or hypothetical digital information from IoT data, digital models, third-party data and business system information. It helps train or guide users on how to perform a task through the overlay of digital instructions or real-time expert guidance.

AR provides safety instructions, real-time transfer of knowledge and expertise through digital step-by-step instructions to guide users. Users can also manipulate digital graphics or extend a product interface through an AR interface. This enables them to expand and customise control of product functions, modify digital designs and enhance physical products with digital experiences.

Digital transformation impacts the entire value chain in the following manner:

- Delivery and service. Personalised customer experience, outcome-based revenue models
- Corporate operations. Performance benchmarking, supply chain visibility and planning, process engineering, continuous improvement, workforce transformation
- Plant engineering. Integrated information and control systems, universal connectivity, converged information technology (IT) and operational technology (OT) networks

- Procurement. Supplier visibility, track and trace
- Maintenance and reliability. Asset health monitoring, predictive maintenance, field workforce effectiveness, environment, health and safety management
- Manufacturing operations. Shop-floor workforce flexibility and efficiency, automated touchless factory quality assurance, compliance and analytics, energy monitoring and management, real-time operational intelligence

Bridging the gap between machines and IT

Technologies that can bridge the gap between OT and IT are smart assets, multi-disciplined control and information, secure network infrastructure, mobility and scalable computing. Information-driven manufacturing leads to ease of use, better quality control, increased safety, increased productivity, improved design through simulation (CAD/CAM), energy savings, reduced labour costs, reduced or removed routine manual and clerical tasks, and so on. It requires building a collaborative team, reliable and secure infrastructure, technology upgrade for the digital world, developing skills (educating and training employees), partnerships to close the gaps and solve challenges for successful digital transformation.

Between OT and IT, there lie various manufacturing operations and management processes that help achieve a connected enterprise. OT includes materials and transport, machines and testers, controllers and scanners, and 3D printers. Whereas, IT includes ERP, financials, HR, logistics, quality and warehouse.

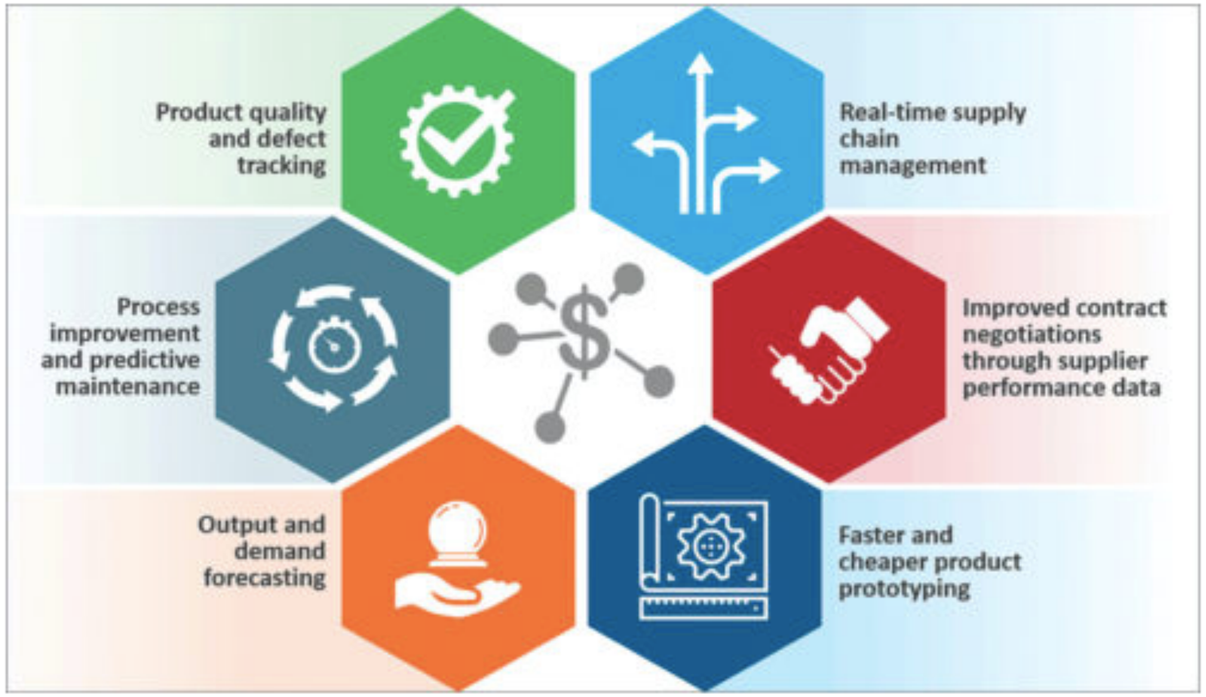
Smart in-line inspection systems and plant monitoring systems

Defining a problem gives half its solution. Utilising resources effectively, capitalising human resources intelligently, managing finances and deploying the right technology can solve any business problem. Trending technologies applied in Industry 4.0 are the Industrial IoT (IioT), RFID, AR and virtual reality (VR) for enhanced visualisation and learning, cyber physical systems, computer vision, 3D printing with multi-material capability, automated guided vehicles, private LTE-enabled connectivity, cobots, smart sensors, network security, implementation of OPC Unified Architecture (OPC UA, a machine-to-machine communication protocol for industrial automation), actuators and controllers, additive manufacturing, digital twins, wireless instrumentation, cybersecurity and industrial design.

A cyber physical assembly line includes the following smart machine interactions: voice interaction, WhatsApp messaging, voice calling, augmented experience using AI, machine learning, NLP and analytics, remote access to human-machine interface (HMI).

Maintenance and electrical fault finding can be achieved in four steps, as explained below.

- Design a CAD model, which is a digital replica of a physical system.
- Create an electrical schematic design. When synced with the CAD model, add electro-mech layer of information.
- Apply the IIoT. It provides data, which when analysed gives detailed information about the machine's running state.
- Apply AR as GUI to digital data in a user-understandable format.



Benefits of Industry 4.0 to manufacturers (Credit: www.everestgrp.com)

Preparing an enterprise for digital connectivity

All industrial revolutions have been driven by innovation and technology. For the first industrial revolution, mechanisation was the driver and steam, the enabler.

For the second industrial revolution, mass production was the driver and electricity, the enabler.

For the third revolution, PCs, connectivity and automation were the drivers and IT, the enabler.

For the fourth revolution, the IoT, artificial intelligence (AI), cloud, robotics, AR, VR, mixed reality (MR) and chatbots are the drivers, and connectivity, the enabler. The fourth industrial revolution is powered by connectivity, and has enabled expanding the scope of business-critical applications. To unlock this, it is important to become adept at controlling the physical with digital means.

Success of industrial automation depends on reliability, connectivity, distributed intelligence, transparent IT architecture, security, easy integration, flexible transport, additive manufacturing, standards and software services.

The digital value chain for Industry 4.0 can be split into seven key components, as follows:

1. Machines/devices. Ecosystem-based approach, leveraging on existing deployment
2. Network. Multi-access network management, proposing the best technology

3. Platforms. IT infrastructure-interface enablers, platforms to nurture ubiquitous approach
4. Applications. Industry-specific use-case, machine learning and analytics
5. Solutions. Business ease creation, solution design and delivery
6. Operations. Project implementation and support
7. Project management. Maintaining network and applications uptime, periodic upgrades for security and operational improvement

Connectivity is paving the way for such industries as automotive, oil and gas, banking and finance, IT, power and production, to be ready for Industry 4.0. There are verticals like real-estate, healthcare, project development, trading, aviation and others adopting LTE in this direction.

Some industrial automation use-cases

Nokia and BSNL have collaborated for Industry 4.0, and have moved from traditional wired factory networks to wireless networks, leading to improved equipment mobility for enhanced flexibility of manufacturing infrastructure. Early adoption of IIoT applications in industries have improved productivity and operational efficiency, too.

Rockwell Automation's transformation results have been as follows: delivery gone up from 82 to 90 per cent, lead times reduced by fifty per cent, productivity increased more than five per cent and thirty per cent reduction in capex.

PTC AR by Vuforia studio provides powerful AR content creation for enterprise content creators and publishing solutions for industrial enterprises. Vuforia engine has use-cases in inspection and manufacturing operations, marketing and sales, presales manufacturing process services, training and project reviews.

Surface inspection systems for digital TV production by Samsung reduce human operator intervention in the production line, increase throughput and reduce errors in product inspection. System operation supports capturing TV surface image from high-resolution camera devices.

Samsung has also developed a post-processing system for an image captured by the camera to make it amenable to automatic detection. Automatic surface defect detection algorithm on a pre-processed image enables distinguishing of a real defect from a false one on the digital TV.

The connected cyber physical world has brought availability of information and ease of dissemination of information. Information-driven enterprises have enabled optimisation of resources. Leakage or waste can be minimised through connectivity, technology and transparency. For example, a 45kg coal wagon going from Jharkhand to NTPC plant

results in at least thirty per cent wastage in resources. With the right technology connecting the point of source to the point of use, NTPC has to pay only for the coal that lands at the plant. This can be achieved through weighing the wagon at different locations through the whole passage, and this information connectivity can reduce under-invoicing and over-invoicing. This ultimately benefits the end consumer, reducing the price of per unit electricity.

Government and industry initiatives

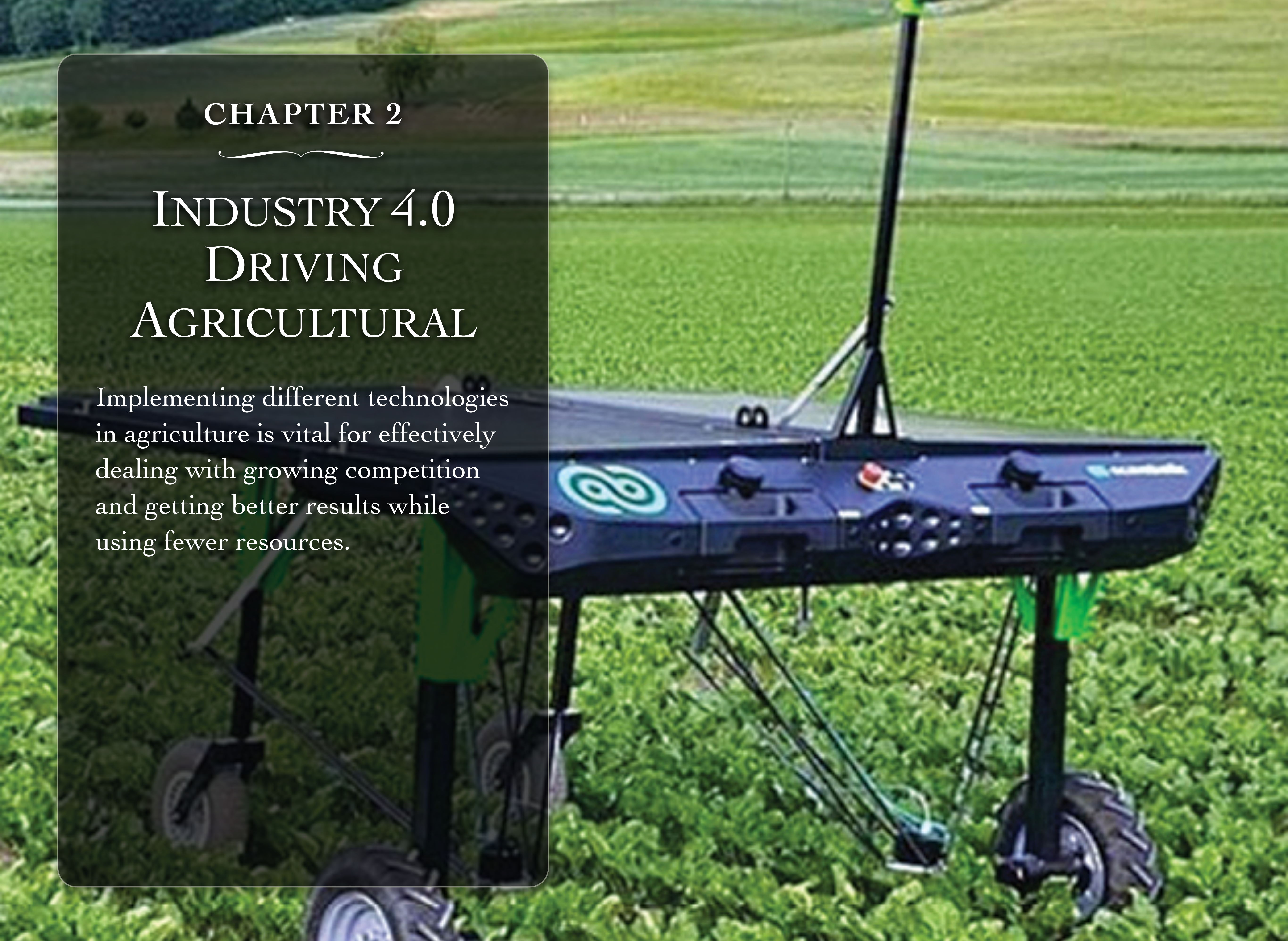
By anticipating challenges before they arise is more likely to offer a successful digital transformation. Challenges experienced are lack of understanding, lack of scalability and poor workforce skills. Driving the next industrial revolution by reinventing 3D can help achieve immersive and easier designs and prototypes, and the final part of digital production.

Government initiatives for fuelling manufacturing leadership and innovations redefine and create new value opportunities.

To strengthen Make in India ecosystem with the adoption of smart technologies, Automation Industry Association and research institutes like IIT-Delhi and others have created a special-purpose vehicle, called Foundation for Smart Manufacturing (FSM), to take the emerging wave of smart technologies and adapt it with relevance to the needs of the Indian industry.

To facilitate, introduce and enlighten the industry with an evolved genre of quality-focused smart manufacturing, Department of Heavy Industry (DHI) supported by IITD-AIA Foundation for Smart Manufacturing (FSM), Federation of Indian Chambers of Commerce & Industry (FICCI) and IIoT India has been organising workshops to empower different industrialists to achieve the benefits of Industry 4.0.

Digitisation in the industrial manufacturing segment is about using capacity and a properly-calibrated information-driven solution to solve problems and reduce pain-points in the enterprise. And, early adopters of technology always benefit more by the industrial revolution digitisation.



CHAPTER 2

Industry 4.0 Driving Agricultural

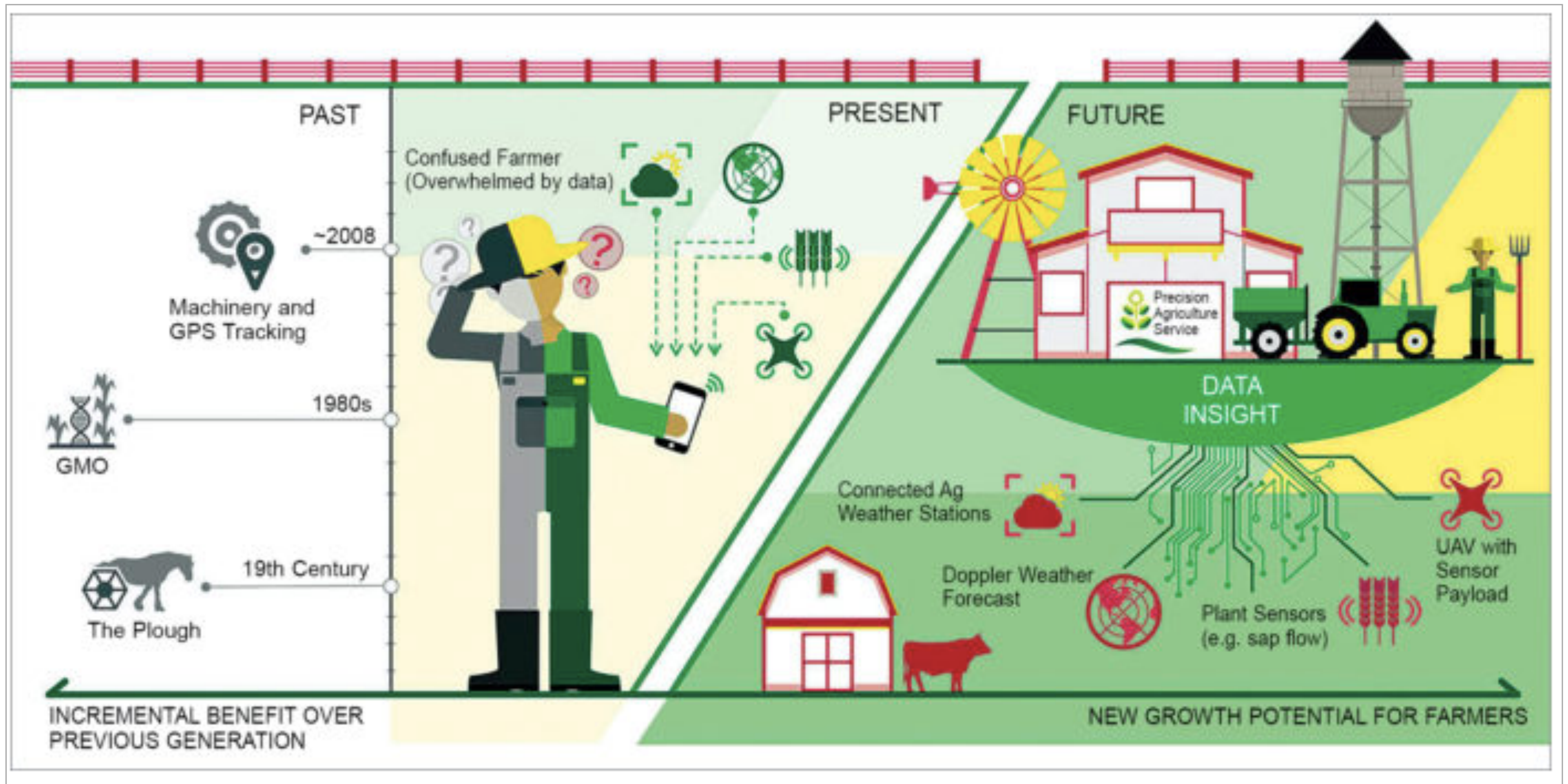
Implementing different technologies in agriculture is vital for effectively dealing with growing competition and getting better results while using fewer resources.

Industry 4.0 Driving Agricultural Revolution

-By Ayushee Sharma

Green revolution changed the face of agriculture in the 20th century. While the purpose, that is, growing crops and maintaining livestock remained the same, methodologies changed and that had a significant impact on results. Now, with latest disruptive technologies in Industry 4.0, agriculture is up for a technological revolution. This is the need of the hour owing to the increasing demands of the growing population, which have led to more intensive farming practices. Modern agriculture requires a sustainable yet more efficient approach, which is termed as smart farming.

Adoption of the Internet of Things (IoT) for agriculture has been the main push in boosting the volume and quality of items in the industry by enhancing the quality of crops and fertility of the land over the past few years. IoT components comprise mainly smart sensors and devices, connectivity, data processing and analytics, and user interface. Artificial intelligence (AI) and computer vision have made it possible to remotely monitor farms and analyse data.



(Credit: https://medium.com)

"Smart farming can support more productive and sustainable farming via an accurate and resource-efficient approach. The potential for smart farming is huge.

The farming industry has only just begun to make use of digitalisation," says Dr Jan Regtmeier, director product management, HARTING IT Software Development.

Evolving methods for all-season farming

Not having accurate knowledge of climatic conditions in an area results in low-yield and low-quality crops. Devastated crops result in higher prices for consumers in the market. For enhancing the yield of crops without worrying about climatic conditions in a place, new ways of farming have come up. Automated agriculture has made indoor agriculture possible, thereby preventing land deterioration and increasing production of reliable food supply.

The concept of vertical farming is being adopted at a rapid pace. Vertical farms cultivate crops and raise cattle inside dedicated or mixed-use skyscrapers, which meet the growing requirements of urbanisation. This way plants can grow without sunlight. As sensitivity of crops to light varies based on wavelength, energy-efficient lighting using LEDs can ensure that light levels are optimised. Green Sense Farms has developed a commercial farm that utilises LED lights that are customised for each crop. Advantages of such a system include efficient crop production irrespective of weather, so that consumers get fresh food throughout the year at low rates.

Smart greenhouse-based farming is one method where such environmental parameters as pressure, humidity, temperature and light levels are monitored and controlled with the help of IoT-based sensors without the need for manual assistance, which increases accuracy.

AgritechMurcia platform consists of numerous agricultural technology firms that work on projects for providing ideal farming solutions. One such project developed as part of this is construction of greenhouses for organic farming.

When connected to a cloud server, the system can be remotely accessed to enable data processing. Many platforms are available for translation of data into actionable insights for farmers. Sensors can control actuators through Wi-Fi signals to perform different tasks, including regulating the heater, change light levels and more. In addition to decreasing costs, to make it eco-friendly, solar-powered IoT sensors can be used. Emails or SMS alerts can be sent to the user regarding the current state of variables.

Ag-tech tools and techniques for crop cultivation

Precision farming is the most popular end-to-end application of the IoT in the agricultural sector. Companies like Arable, Gamaya and CropX are some of the key names in this field. Gamaya, for example, focuses on large-scale monitoring and diagnostics through hyperspectral imaging and Big Data. The business has smart solutions for soybean and sugarcane cultivation.

Using precision farming, instead of applying inputs like water, fertilisers and pesticides uniformly across the field,

farmers target a specific area or even a single plant and apply inputs that optimise crop production.

Real-time weather data collected through weather stations or by different sensors includes information about various parameters like humidity, rainfall, temperature and more. Alerts are sent if weather conditions are unsuitable. US-based aWhere is one such company that gives smart climate insights using machine learning algorithms to farmers, crop consultants and retailers.

Soil parameters measured using sensors are texture, salinity levels, nutrient status, organic content, etc. Trace Genomics has developed an analytics engine to map the living soil and protect it.

It allows farmers to make better decisions about the crops that can be grown, their harvesting and future-planning for that land. By optimising planting of seeds, better seed-spacing and depth-control are guaranteed. Based on the amount of light reflected back to the optical crop sensors, sensing the correct amount of fertilisers needed by the crops is done in real time to prevent runoff of excess chemicals into nearby water bodies.

Variable-rate applications (VRA) are centred on understanding the relative productivity of different areas based on data obtained from sensors. Automated equipment and machinery can then be used to optimally apply herbicides, fertilisers and the like at variable rates and prevent overlapping. Maps and GPS ensure that machinery navigation and positioning are accurate. Nano-materials-based pesticides and insecticides further improve precision.

Drones, both ground and aerial, are being used for crop planting and monitoring, field analysis, etc these days. With thermal or multispectral sensors, irrigation patterns essential for various fields can be identified. Irrigation can be controlled remotely through a PC or mobile. Benefits include integrated Geographic Information System (GIS) mapping as well as saving time and possibly increased yields. Several companies like DroneSeed, Agribotix, Skycision and HiveUAV have been providing drones for agricultural applications. Using drones, farmers can remotely manage crop operations without being a drone expert.

Utilising optical sensors, drones and satellite imagery, it is also possible to assess the health of various crops. Using mobiles and tablets, any pest population or weed activity on the farm can be checked, and then effectiveness of pest- and disease-control procedures can be evaluated. One of the most common methods is Normalized Difference Vegetation Index (NDVI). It uses wavelengths of infrared (IR) and visible light to detect crop variability and different crop stages.

Many companies are also building farm robots. These are commonly used for automation of agricultural processes like planting, irrigation, weed management, harvesting crops, fruit picking, ploughing, soil maintenance and so on. For instance, Ecorobotix and Blue River have come up with

robots that can identify weeds in real time using cameras and communicate the information to another piece of machinery through telematics to decide on the appropriate action that needs to be taken for dealing with them.



Smart weeding robot (Credit: https://en.reset.org)

Once crops are harvested, impure crop shipments can be avoided through electronic security tagging. This enables transparency to a great extent. Once consumers are aware of the entire supply chain, it is easier to prevent food-borne diseases.

Livestock monitoring

The IoT can also be used to gather information about the location and health of cattle. Installing cameras around barns and pastures enables remote monitoring of animals from anywhere. Collars with radio frequency identification (RFID), which can be low, high or ultra-high frequency, GPS and biometrics can automatically identify and provide important data about the livestock, such as birth date, mother's and father's ID numbers, offspring, veterinarian records and so on in real time.

Apps like Connecterra IDA are used for getting updates about the animals. This way each animal gets special attention and a database of their history can be maintained. This also assists in easily locating and separating sick animals from the rest to prevent spreading of disease. For example, CowManager by Agis Automatisering is a cattle-tracking sensor and software solution.

For preventing animals from going to unwanted places, conventionally low-voltage shocks and sound stimuli have been used. Several organisations are building harmless and cost-effective alternative solutions for this. Vence, for instance, has created a virtual fencing wearable for cattle.

Ultrasounds can check the quality of meat that can be obtained from an animal even before reaching the market. Research is ongoing to create different kinds of foods (meat and drinks) by manipulating genes in the future.

Software and platforms for data management

The IoT sensors collect a huge amount of data that cannot be stored on a conventional database system. Cloud-based data storage and end-to-end IoT platforms ensure that data related to weather, livestock and crop get analysed using tools for predictive analytics.

Many apps available in the market can be used for real-time data collection by field teams and to send updates. Software platforms like Cropio pile data from different hardware devices used in precision agriculture on a central platform for processing and analysing, which is crucial for making effective choices for managing farm operations. Data platforms provide aggregated data to farmers at a single location as a resource. Task management tools can easily create budgets and operation strategies for production, and compare yields against standard values.

Challenges

Many farmers are reluctant to change because they cannot afford the expensive tools and machinery required, while others are not aware of the benefits. In cases where land is not owned by the farmers themselves, there are lower chances of investment. Besides, several farmers in developing and underdeveloped countries lack the needed educational qualifications. In developed countries, the average age of farmers is quite high. This

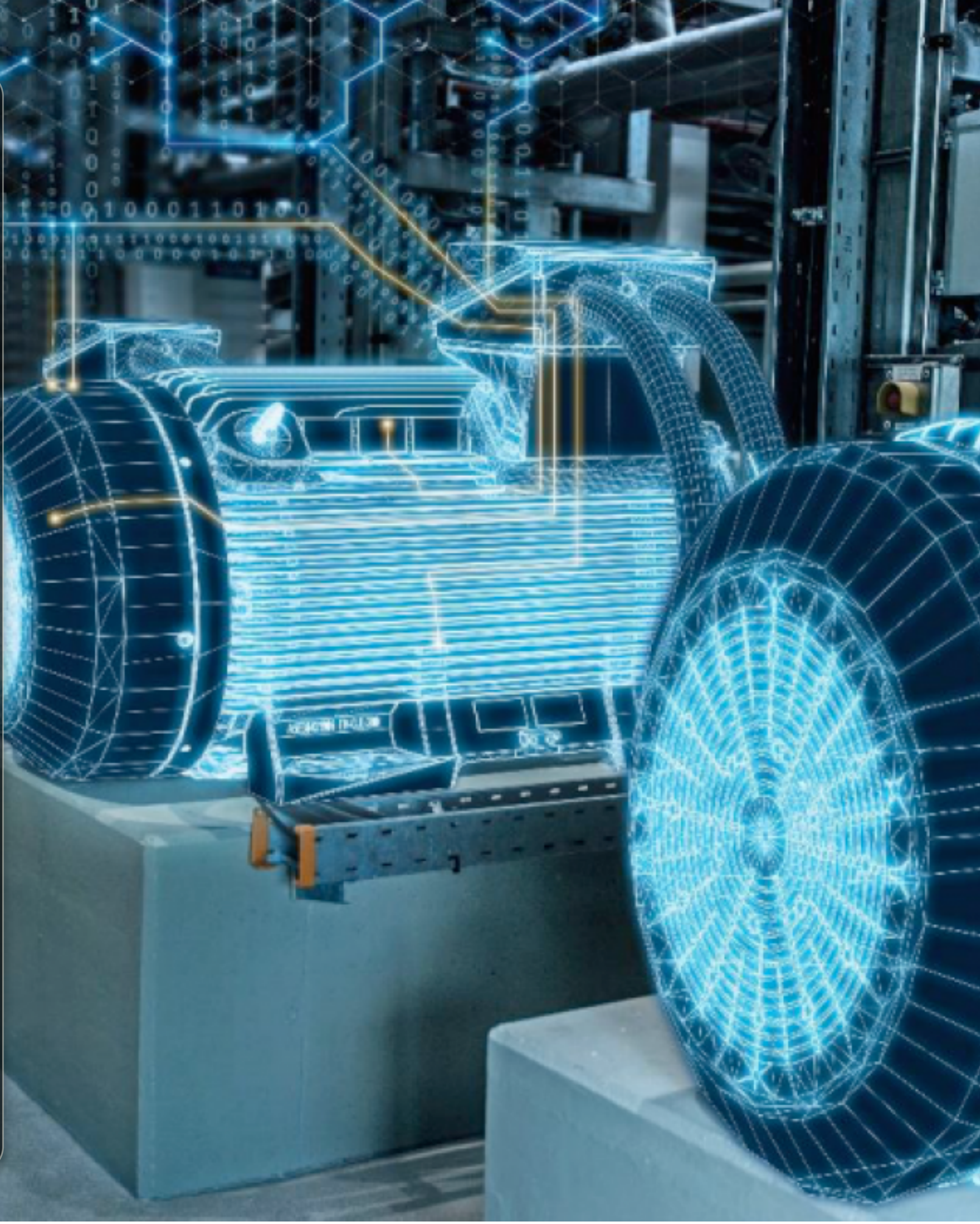
impacts their decision-making and capability of learning new technologies.
In using all these technologies, an Internet connection is a must for strong network communication. In places with poor connectivity, farmers have to struggle to make them work, which impacts their motivation.

Implementing different technologies in agriculture is vital for effectively dealing with growing competition and getting better results while using fewer resources. Crop-harvesting robots, like those by Harvest CROO Robotics, can make up for the lack of enough workforce in developed nations. For staying in business, adoption of these measures is not optional but mandatory. Before making any decision on long-term investments, farmers should consult experts and fellow farmers regarding potential benefits. It is not only necessary for owners but also for employees to learn to work with these technologies.

CHAPTER 3

Challenges for Industry 4.0 IoT

Manufacturers today face unprecedented challenges majorly on pricing, competition and complex global supply chain disruptions to find newer ways to boost the efficiency of one of the oldest & largest industry vertical.



Challenges for Industry 4.0 IoT

By Dadheech Girish

Almost 50 years ago the world witnessed (frankly not me!) the age of industry 3.0 standards, that era carried long has given the manufacturing its very own edge, but with rise in cost of production, decline in manufacturing and mostly lifeless process has driven the industry to its verge. With communication standards massively innovated in last 2 decades, manufacturing standards had no choice but to sync with innovation which drove the industry to spearhead its journey towards industry 4.0 revolution.

The word "revolution" is very specific here as industries will take the help of new age communication technologies to merge it processes & connect machine to machine. Or in layman terms, the intelligent networking of machines and their legacy processes, with Internet of Things (IoT) ubiquitously is industry 4.0 standard.

"..WITH RISING INDUSTRY PROTOCOLS CUSTOMERS ARE OVER-BURDENED WITH PLETHORA TECHNOLOGY OPTIONS, WHEREAS CUSTOMER ONLY SEEKS ANSWERS AND NOT THE PROCESS TO OBTAIN THE ANSWER.."

Having spoken to many end customers (especially industry owners) on adoption of IoT, I realized that with rising industry protocols customers are over-burdened with plethora technology options, whereas customer only seeks answers and not the process to obtain the answer. Just imagine you seeking a resolution to a tooth pain, whilst doctor is busy explaining the origins & reliability of his equipment such as probes, excavators, curettes & forceps, whereas all you want is an "assurance" that the pain will be relieved at specific fix cost with no hidden tantrums when you are on the hot seat.

Before you raise eyebrows on this analogy, I do agree that there are certain specifics a customer would be keen to know but certainly not really deep & wide of it. Hence, I summarize the specifics of their concerns,

Seamless Connectivity

The most feared area when it comes to communication, that also plays a key role in their decision for their use-cases, For years we've ourselves felt the disconnect over a wireless connectivity, albeit Bluetooth or WiFi, frankly never mind the most hyped HD video on a 4G connection in a cave mouth, seriously that joke went too far ! All they need is data availability & accuracy to be in range of 99.99 & beyond. And honestly they are least interested in your protocol vocab if you trying to grab their attention.

"..FOR YEARS WE'VE OURSELVES FELT THE DISCONNECT OVER A WIRELESS CONNECTIVITY, ALBEIT BLUETOOTH OR WIFI.."

Convergence of Internet & Operation technologies

Now that we are attempting to interconnect all legacy machines via IoT sensors earlier that worked in silos with their own whims & fantasies, suddenly that would start throwing data about temperature, humidity, vibration, battery, flow etc left & right. Also, over the time manufacturing had an evolving IT processes like Six Sigma, Kaizen etc and with our newly interconnected machines knowing their rights now, there comes a complicated process to understand and integrate new data streams from machines in sync with the operational technologies.

Operational Cost Efficiency

Investment is not a hobby, especially when you are a production owner, you shall consider technology upgradation only in an phased manner, as funds infused should not be sky rocketing, when we are only digitizing machines not creating a new product. One way to answer this challenge is to target operational efficiency, that can be improved with upgraded supply chain process from in/outbound deliveries, areas like workers health & safety would also raise workforce productivity and less churn that would reduce the overall loss of production hours and chaotic delays. Having said that RoI should be visibly guaranteed and shouldn't sit on an edge of cliff like a "hope".

"..MUST BE STORED SAFELY OVER A CLOUD OR A PRIVATE DATA CENTER FULLY SECURE FROM THE THE DARK SIDE OF CYBER WORLD.."

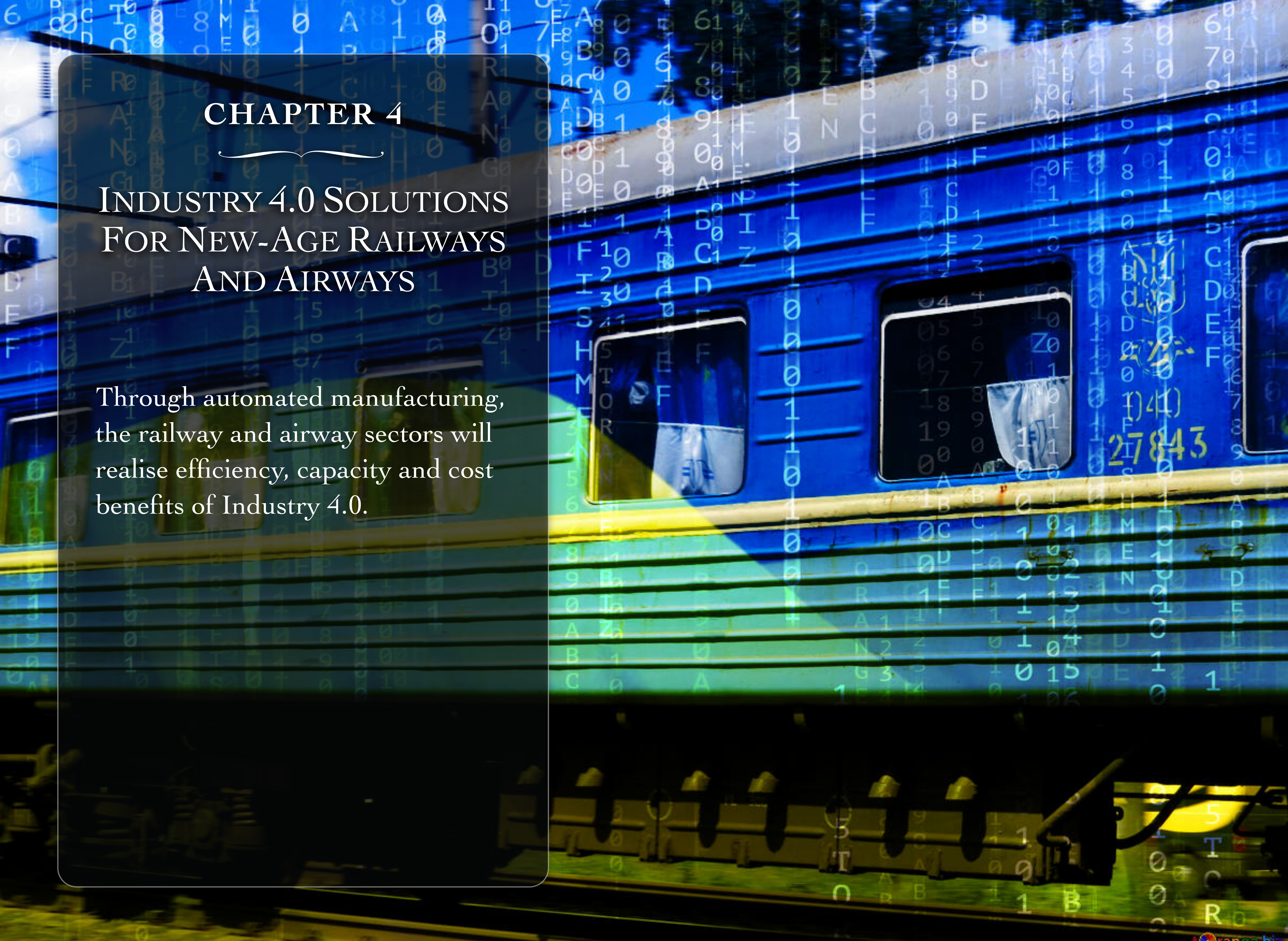
Secure IoT Data Lake

With machine churning out data packets every now & then, that will be used in getting an historic reference on its production which is similar to our health data and records. This must be stored safely over a cloud or a private data center fully secure from the the dark side of cyber world. Likewise, you don't want to employ an elephant to move a chair neither you want your health data to be sold to insurers that raises your premium overnight. This thought process has to be validated while identifying various opportunities for the customer.

Actionable Insights

Certainly, there are the tremendous benefits that can be derived from historic & near real-time insights, most importantly predictive maintenance although not limited to. It also allows an invaluable insight that could cost you $$ if not catered on time. This combination of IoT and historic data will allow regular actionable insight to create a holistic view of company's assets right from machinery, vehicles, inventory & people.

Finally, back on the factory floor, IoT can transform small to large manufacturing industries to a futuristic smart factory, a step taken by leading manufacturers like Airbus to manage aviation manufacturing complexity using IoT technologies such as LoRaWAN.



CHAPTER 4

Industry 4.0 Solutions For New-Age Railways And Airways

Through automated manufacturing, the railway and airway sectors will realise efficiency, capacity and cost benefits of Industry 4.0.

Industry 4.0 Solutions For New-Age Railways And

There is no established path for success of any emerging technology, but creating a roadmap can help the rail and aviation industries to bring a more digital and connected future. The need for these industries to be smart is there because Industry 4.0, or the fourth generation of industrial activity, ensures reliability and safety to these sectors.

With automation of the manufacturing industry, these sectors will realise efficiency, capacity and cost benefits of Industry 4.0. Enhanced industry-wide condition monitoring will also help reduce unplanned maintenance. Both sectors are in constant search for improvements to deliver better and secure customer experience.

Transportation systems are complex with respect to technology and operations due to the involvement of a wide range of human actors, organisations and technical solutions. There is a need to apply intelligent computerised systems for the

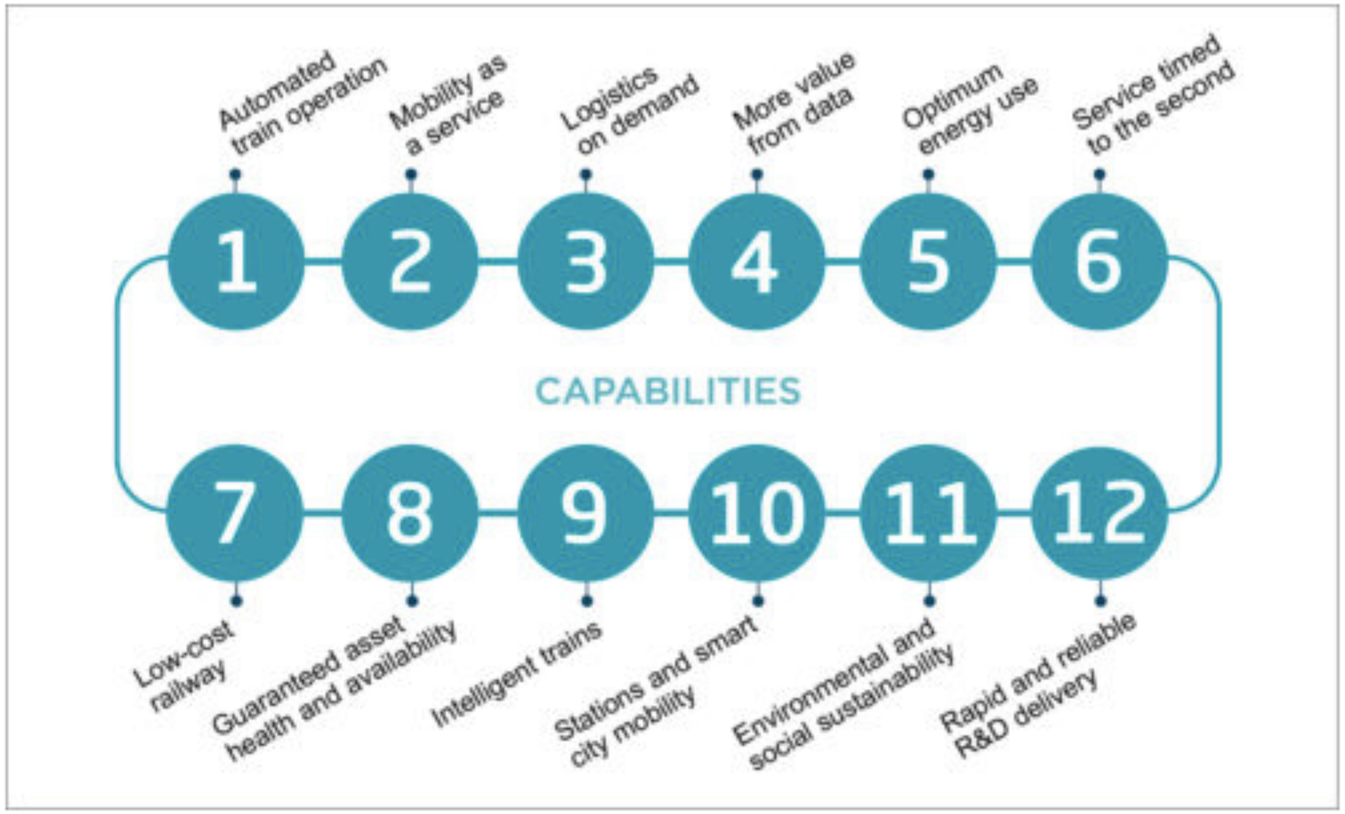


Fig. 1: Twelve capabilities required for the realisation of Shift2rRail vision (Credit: https://shift2rail.org)

operation and control of such complex environments, such as computerised traffic control systems for coordinating airline transportation.

Industry 4.0 is enabled by smart systems and Internet-based solutions. Maintenance is one of the application areas of self-learning, and smart systems can predict failure and trigger maintenance by making use of the Internet of things (IoT).

Digital railway solution

The digital railway programme is focussed mainly on digital signalling technology, which aims to enhance safety and speed up train movement in a congested network. If all data from signalling, rolling stock and passenger traffic control systems is brought together on a common platform, the entire network will be able to communicate seamlessly and instantaneously. The key to digitisation is interoperability of systems while retaining a critical approach to data security.

Rail service information could even be integrated with other transport modes, such as bus and taxi services, to guide passengers through smooth door-to-door journeys. Holistic data management could lead to the transformational change in real-time intelligent traffic management and in-cab signalling. This could improve customer satisfaction, with station information systems and personalised messaging providing passengers with all the relevant information they need.

Digitisation of railways includes:

- B-scan ultrasonic rail flaw detection (both non-stop and stop-and-verify systems) and track inspection with automated high-speed test trains.
- Train control system levels 2 and 3 for high-density routes to increase network capacity and maintain the required safety standards.
- Increased surveillance of personnel with both interior and exterior locomotive-mounted video surveillance to improve monitoring.
- Track-laying machines for mechanisation of construction.
- Electrification through machines such as self-propelled overhead electrification laying trains.
- Complete train scanners for improved diagnostics and maintenance.
- Use of distributed power to improve the efficiency of train operations with coordinated acceleration and deceleration.
- Establishment of smart railway stations by implementing access control at entry points.
- e-ticketing with services such as infotainment and app-based systems.
- Use of training simulators and virtual reality (VR) training systems to improve personnel capabilities.

Digital twin—the digital platform for railways and airways

A digital twin refers to a virtual replica of a physical asset, like an aircraft engine or a rail engine. It is a vital element of the digital rail solution that is continually updated as per the rail network. It enables engineers to test detailed what-if scenarios that could help in decision-making around the planning of enhancement and maintenance programmes. It could identify the most-valued solution that would have the greatest efficiencies and minimise disruptions.

Every year unplanned maintenance, flight delays and cancellations cost millions of dollars to every airline. Optimisation of operational availability can reduce operating costs due to maintenance. Monitoring engines in use with a digital twin can help airlines achieve this. A digital twin can display how the engine is running to engineers on the ground, while the aircraft is still in the air. Later, it can be linked to IT systems to help streamline and optimise maintenance processes and operational availability.

For each asset, engineers compile thousands of data points specifically during the design and manufacturing phases of the engine. These are then used to build a digital model that tracks and monitors an asset in real time, providing essential information throughout an asset's lifecycle, such as engine temperature, pressure and airflow rate.

These virtual models of the assets can provide early warnings, predictions and even a plan of action by simulating what-if conditions based on weather, performance, operations and other variables. This way these models help keep the aircraft in service for longer.

Role of sensors in predictive maintenance

Sensors are constantly getting cheaper. This will increase their implementation as a leading real-time data provider. Sensors use a reaction-based approach to manage and maintain an asset and maximise its use potential. A wide range of sensors is available to collect huge amounts of data from all possible systems of a single train and then analyse it in real time to detect problems before these actually occur.

Constant monitoring of equipment through the measuring of all relevant variables such as temperature, vibrations, oil levels and the like help anticipate the optimal timing for maintenance. It enables identification of faults proactively and elimination of necessary maintenance interventions. Predictive maintenance is a powerful tool that helps track asset health, reduce unplanned downtime of equipment and minimise the high cost of unscheduled maintenance.

Optical and tactile sensors such as light curtains, camera systems and dynamic pressure-sensitive mats are suited to monitoring areas near rail vehicles. Good internal communication, fast reactions based on equipment geolocation data, high-quality maintenance planning and

regular interventions are required to keep massive rail networks working.

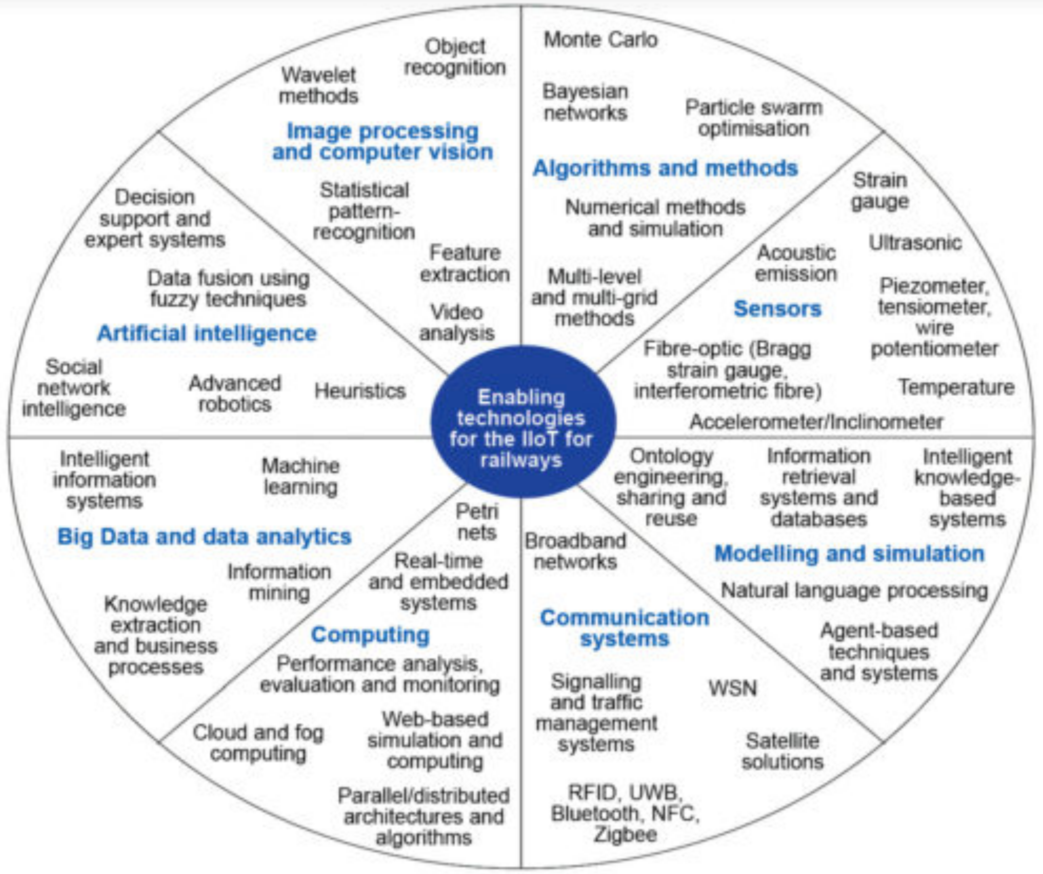


Fig. 2: Enabling technologies for the IIoT of railways (Credit: www.mdpi.com)

Predictive maintenance and CMMS for improved railway asset performance

Modern, next-generation asset and maintenance management starts with the adoption of a smart computerised maintenance management system (CMMS). Reliable railway maintenance is required to improve critical issues like safety, delays and overall system capacity. It is expected to rely on smart transportation systems and interconnected solutions such as predictive maintenance.

An interconnected CMMS can help maintain, manage and connect tracks, terminals, rolling stocks and communications infrastructure. It can identify maintenance issues before these impact safety, operations or revenue. It collects, stores and analyses data to prevent breakdowns and issue predictive maintenance algorithms to extend equipment life.

A reliable CMMS should be user-friendly, fast, reactive and flexible. It should also have a mobile application for anytime access, connectable to ERPs and IoT systems, geolocation tool, an analytical tool that supports unrestricted media upload and so on. Different departments such as accounting, operations, purchase and maintenance should also be connected to the entire communication platform. It can work as a network for manufacturers, technicians and suppliers to exchange expertise and speed up operations. Advanced CMMS analytic tools enable organisations to analyse data with great speed and accuracy, to optimise availability and increase the life of assets.

The IoT-connected trains

The IoT can interconnect all objects and devices that were previously not part of a network for predictive analytics. Its application increases safety, efficiency and ease of use with train management systems. Control and surveillance systems reduce the risk of collisions and regulate speed. Advanced

consumer technologies help maximise connectivity and allow passengers to continue their activities on smart devices while travelling. Train-to-train communication through the cloud enables operators to transmit data about equipment, tracks and stations among themselves.

The IoT enables monitoring of areas on railway crossings remotely, such as barrier operations and end positions, switch end positions, space between barriers, system operations, connections and signals. This allows users to accelerate their projects, from engineering and runtime to maintenance with fast detection and localisation of errors and faults.

Big Data analytics for smart railways

The complete Big Data architecture includes the IoT and cloud computing devices. These work together to create smart railways that have self-learning capabilities to predict failure, make diagnoses and trigger maintenance actions. The architecture utilises multiple data sources to extract relevant information. It helps users to know what happened when, so they can go back and do the root cause analysis from the data, and take appropriate corrective action.

Big Data analytics in railways lead to predictive analytics and make decisions based on huge amounts of data. These involve data collection, analysis, visualisation and decision-making for assets.

Estimation of the remaining useful life of an asset to ascertain the probability of its mission accomplishment is key to the success for any organisation. The railway domain can achieve data interconnection via the train bus where most railway sub-systems and their respective sensors are accessible for global optimisation.

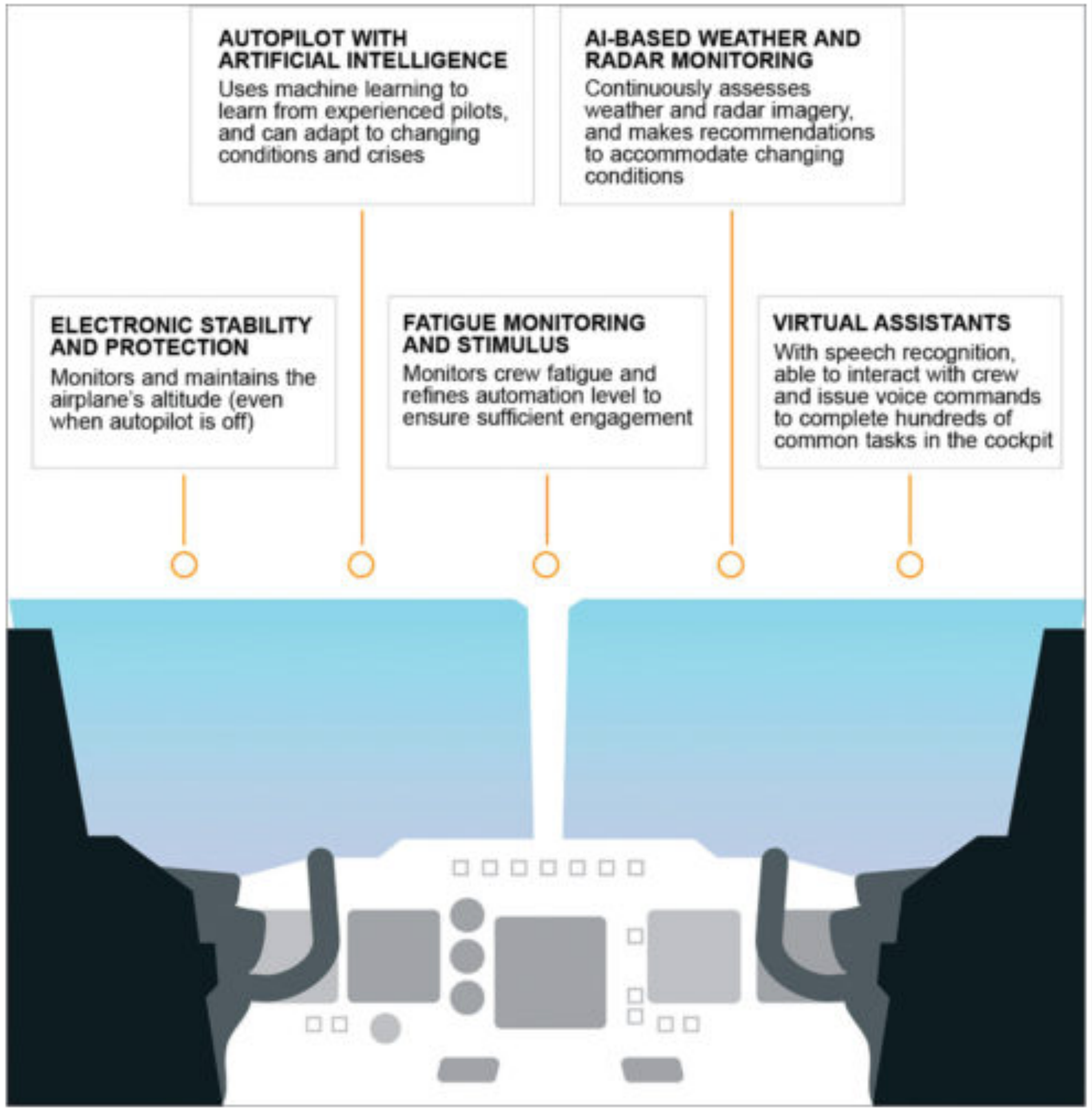


Fig. 3: Possible automation of the cockpit (Credit: www.oliverwyman.com)

With the increase in demand for more passenger rail services and greater volumes of cargo trains, use of data and its analysis will become a primary asset for the railway sector. Millions of data points captured from sensors on critical train components will help detect impending part defects, ensuring maintenance before a defect occurs. This will improve reliability of the system infrastructure for many years by remote monitoring of location and condition of all vehicles.

More technologies to meet needs of the railways

Researchers at Siemens Corporate Technology have developed a technique known as frequency-selective coating of window panes to solve the problem of low mobile Internet signals. These panes are provided with a transparent electrically-conductive layer consisting of metals or metal oxides. Metallic coating of the windows is vaporised along lines in a special structure by a laser to pass certain frequency ranges unobstructed.

The VR lab at GE Transportation's John F. Welch Technology Centre, Bengaluru, facilitated a 3D VR environment for inspection. It tracks the motion of inspectors through specially-designed wearable goggles and infrared (IR) cameras placed in the room. The VR controller allows users to interact with individual components. The environment helps teams at different locations collaborate and review products that are under development. The lab can also be used as a training ground for service engineers who work on products in the field.

Locotrol distributed power system is a control and communication system that enables coordinated braking and traction power distribution between lead and remote engines for faster stopping times and shorter stopping distances. Locovision system through superior image quality cameras and real-time data processing monitors wayside assets, measures track gauges and detects intruders. It stores all information in a hardware infrastructure to help avoid major asset repairs and fines. The rail integrity monitor employs innovative technology with mounted sensors under the locomotive, continuously testing rail integrity in real time.

Automatic train control systems continuously monitor all train movements to provide fail-safe signalling. Operation of railways is centrally-monitored and controlled through operations control systems. Supervision systems, such as CCTVs or emergency telephones, also contribute to safety and enhanced comfort.

Signalling systems and railway automation solutions are crucial to detect and signal whether line sections are clear or occupied. There are three grades of automation and train control systems, namely, partially automated (supervised by a driver), highly automated (reduced driver supervision) and fully automated (the system is responsible).

Airways technologies and automation

The year 2019 looks to be the era of digital transformation with technology becoming a part of everyday life within all

industries, including air transport industry. The airline industry is constantly evolving and adapting to new consumer habits, expectations and requirements for better safety and security. Technologies and trends that we expect to play the most important role in reshaping the air transport industry in 2019 are:

Biometrics

Biometrics-enabled self-service boarding gates, where your face becomes your passport, have been implemented at the entrances of many airline lounges. Integration of this technology into signages and flight information display systems is used to serve passengers with personalised information and offers.

Biometric technology can also be used onboard to facilitate seatback immigration and simplify in-flight payments. Airlines, airports and their partners are continuously working towards the goal of creating a biometrics-enabled single passenger token to offer effortless journeys.

Biometric technology such as fingerprint scanning or facial recognition on smartphones has also been adopted by airlines and airports to transform the customer journey. Fingerprint scanning for identification purposes to check in baggage could eliminate the need for boarding passes and cut down on the need for crew to be present to manually scan them at the gate.

Blockchain

Blockchain technology can eliminate the need to rely on physical ID proofs by saving passengers' data maintained in a virtual de-centralised database. It can be extremely useful in building a robust security system for managing customer data by using a cloud-based document management solution. This will save time, money and resources in the long run, helping airlines become more efficient, safer and compliant. This data can also be used in increasing the operational efficiencies through predictive analytics.

> Recent advancements in sensors and condition monitoring technologies have led to continuous data collection and evaluation, significantly minimising the number and cost of unscheduled maintenance

Artificial intelligence

Chatbots can be used to answer simple questions, freeing up resources (human agents) for more complex customer service issues. Artificial intelligence (AI) also holds potential in a number of other areas, such as real-time predictive pricing, predictive aircraft maintenance and operational efficiency on the airfield.

Travel experiences can be daunting when you are in an unfamiliar environment and do not speak the local language. This could be solved by AI and machine learning (ML) technologies with translation apps and devices.

Robotics

Robots can assist in various tasks from transporting luggage to proactively identifying potential security risks. Customer-facing robots can provide on-the-spot assistance to passengers like customer management, car parking and so on. Baggage management can also be improved with re-usable electronic bag tags and door-to-door pick-and-drop facility.

Beacon technology for indoor positioning systems. Beacons can make navigation easy for travellers between different terminals at the airport. It can also help to know where passengers are and send them personalised and relevant information accordingly. This information can be about boarding gate number, baggage or flight status, or about the shops around.

AR and VR

Augmented reality (AR) allows passengers to use the camera on their device to view AR directions to wherever they need to go within the terminal. It helps them navigate the complex layout of airports.

VR-based apps can be used for training new crew members and engineers about engine mechanics.

Cybersecurity and cloud

Everything that airlines do to improve their digital touchpoints depend on the security of their IT systems. While technology leaders and industry stakeholders are working on a number of solutions, airlines should keep cybersecurity at the top of their priority list.

The IoT

Sensors can detect and report faults to maintenance teams on the ground, removing the need for the crew to manually do so. Addition of sensors to aircraft seats will enable the crew to monitor individual passenger health and well-being. Sensors such as hydraulic pressure and brake temperature provide real-time data to help predict early malfunctions or diagnose the remaining life cycle of the landing gear. Researchers are developing resilient ML-based autopilot systems that can adapt to changing conditions.

Airlines are using mobile platforms to connect with their customers throughout the journey, starting from booking of a

flight to deplaning it. Deployment of connected objects can transform the manufacturing process with new tools and services that generate a drop in production costs and increase productivity. Overall, it can reduce both time and cost of maintenance.

Conclusion

With the rise of Industry 4.0, railway companies can now ensure that they are prepared to avoid the surprise of equipment downtime. The railway industry is on its way to integrate predictive maintenance and Big Data. Recent advancements in sensors and condition monitoring technologies have led to continuous data collection and evaluation, significantly minimising the number and cost of unscheduled maintenance.

Most significant improvements have been evidenced by more informative and user-friendly websites, mobile applications for real-time information about vehicles in motion, and e-ticket purchases and timetable information implemented at stations and stops. Airline technology is likely to evolve over time to the point where one crew member can handle a sizable chunk of a flight given an anticipated pilot shortage in the future. With automation a remote pilot on the ground will be able to take the second seat on a flight or flight segment.

CHAPTER 5

Industry 4.0 – Building the Foundation For Tomorrow's Digital Manufacturing

Industry 4.0 is no longer a 'future trend'. It encompasses a promise of a new industrial revolution—one that marries advanced manufacturing techniques with the Internet of Things to create a digital manufacturing enterprise that is not only interconnected, but communicates, analyzes, and uses information to drive further intelligent action back in the physical world.



Industry 4.0 – Building the Foundation For Tomorrow's Digital Manufacturing

> For an increasing number of companies, including the forerunners in the industry, Industry 4.0 is now in their strategic agenda. They have started integrating many advanced automation & cloud technologies in their operations, to transform their business.

There is a significant amount of investments in Industry 4.0 and there is an indication that global industrial companies would invest nearly US$907 Billion per year through to 2020, with focus on digital technologies and applications. Training employees and driving organizational change are also gaining momentum. Within the next few years, implementation of advanced smart manufacturing technologies will become a qualification to be in the game. Companies that are prepared to be flexible to accommodate the needs of the customer will actively shape the future of manufacturing.

Emerging trends driving exciting possibilities of the future

Data Analytics

Manufacturers are realizing that the data coming from multiple sources, if fed through effective data analytics could be used to create value & drive strategic decision making. We see an emerging trend where, industries enhance their product portfolio with disruptive digital solutions and innovative, data-based services.

Batch one manufacturing technologies like 3D printing allows digital integration with the customer, thus providing an incredible opportunity for companies to get closer to customers. There is a growing demand for personalized products, a trend that is leading to the mass production of highly customized goods tailored to the individual. This requires an agile supply chain that will cater to these high levels of customization.

The decentralized availability of critical information, irrespective of place and time makes it possible to produce such individual products even to the batch size of one. Additive manufacturing or 3D printing is strongly associated to Batch 1 production, and beckons many new possibilities in the field of industrial manufacturing.

The revolutionary multiproduct line in Bosch Rexroth, Homburg produces 200 product variants in the same line economically and with no retooling effort. The assembly line connects people, machine & products seamlessly through autonomous workstations that reconfigure themselves to suit the production of batch size as small as one product.

Sensors

Sensors are indispensable to a wide range of industries and developments in industrial sensors are happening at a phenomenal rate. Sensor technology is a driving force in the field of IOT and it is revolutionizing our manufacturing plants. They are responsible for sensing which means without them, IoT and it derivatives would be impossible.

Every day, smaller, cheaper and smarter sensors are being introduced – in homes, clothes, cities, transports, energy networks and most importantly, in manufacturing processes. Smart sensors are introduced in every imaginable description that come with the ability to sense critical data, connect to the Internet and exchange information. They facilitate machine to machine communication and help to monitor, control, improve operations and make decisions about processes that are backed by data.

Smart sensors installed in manufacturing equipment automatically log data like temperature, humidity, vibration, hours of operation, etc. Big data is fueled by these smart sensors and their data streams. The availability of humungous amount of insightful data and its variety demands the need and development of new analytics software and systems to process it. Smart sensors enable manufacturers to transition from scheduled maintenance to predictive maintenance that forecasts the event of failure, thereby reducing expensive downtime. Sensors and the digitization of manufacturing processes open the doors to innumerable possibilities towards efficiency, quality and profitability.

Smart Manufacturing will make India an attractive leader

The Indian manufacturing sector is on the brink of scripting a new era for itself and become the fundamental enabler for the country to take up its role as the global manufacturing hub. A paradigm change is expected to be ushered in while the growth of manufacturing sector takes place.

The plant is only one piece – currently, India is at a lower level compared to other countries in terms of plant sophistication. It is many times at pure mechanical manufacturing level. The looked-for level, or top of the

pyramid, is a situation where Industry 4.0 is adopted completely. India is now going global with 'Make in India.'

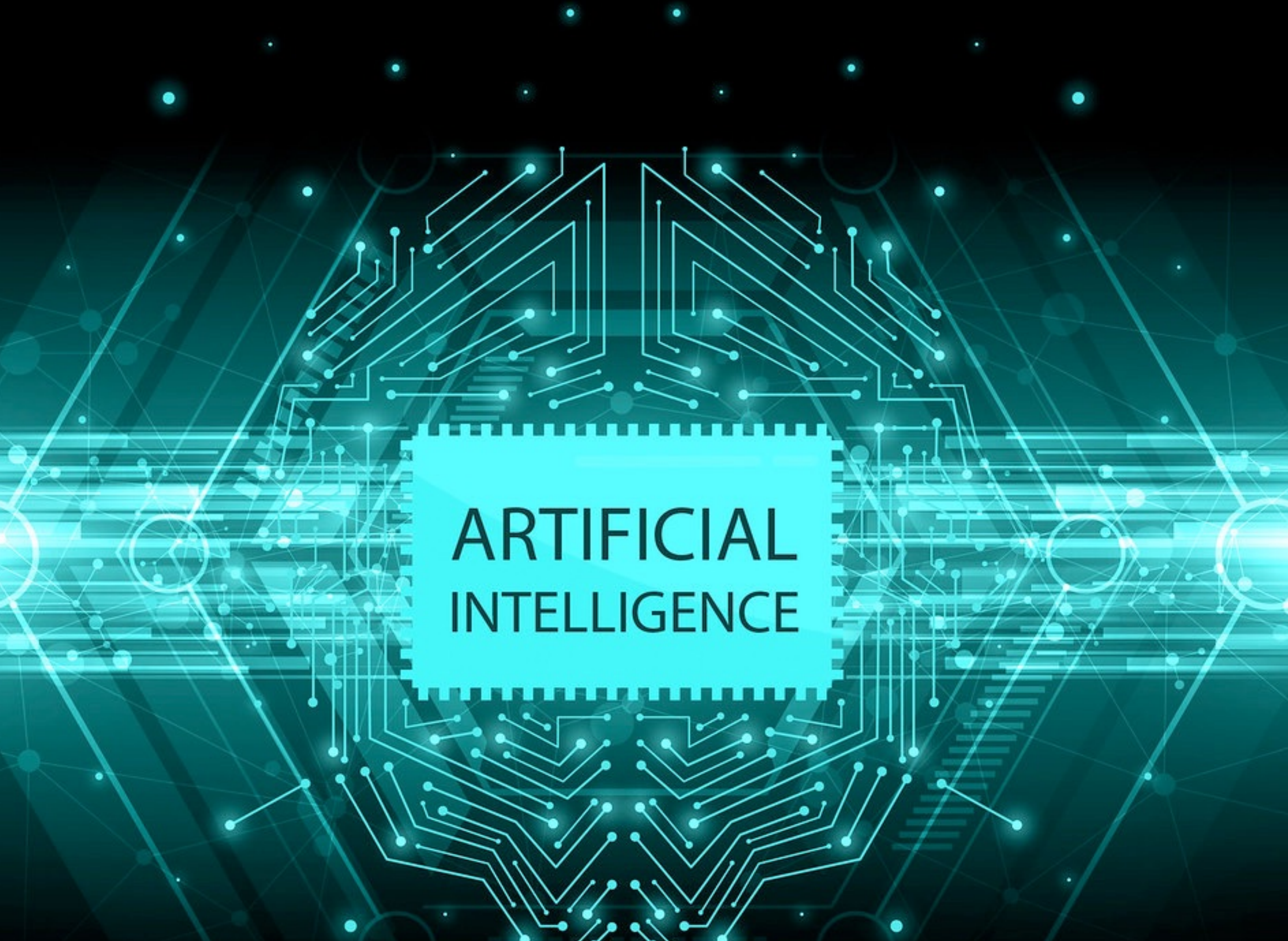
Manufacturing gives millions of people a share in producing products and this is very important for India's future. If India wants to be successful in Make in India, it needs to become the hub for smart manufacturing. This requires a focus on exports. We need to now adapt Industry 4.0 concepts for India. Only this optimization will give us the triumph in India.

The country needs to take the bull by the horns so that the world market is not driven elsewhere like China or Indonesia. Having said that, in Industry 4.0 not everything can be done by suppliers or OEM by themselves. The partners are essential. There is also a potential for us to be successful in being the right partner for the industry worldwide.

The Need

The application of Industry 4.0 is already in progress in industrialized countries like Germany, US. We are presently at the start of such a development, which will gradually become conventional in industry. India seems to possess an inherent advantage in creating attractive frugal solutions with global appeal. India has a well-paid middle class, but the masses are struggling. Industry gets the masses into jobs therefore Modi decides to go for Make in India. The 'Make in India' initiative will also take in a character of smart manufacturing which will guarantee superior adoption of automation and world class manufacturing practices.

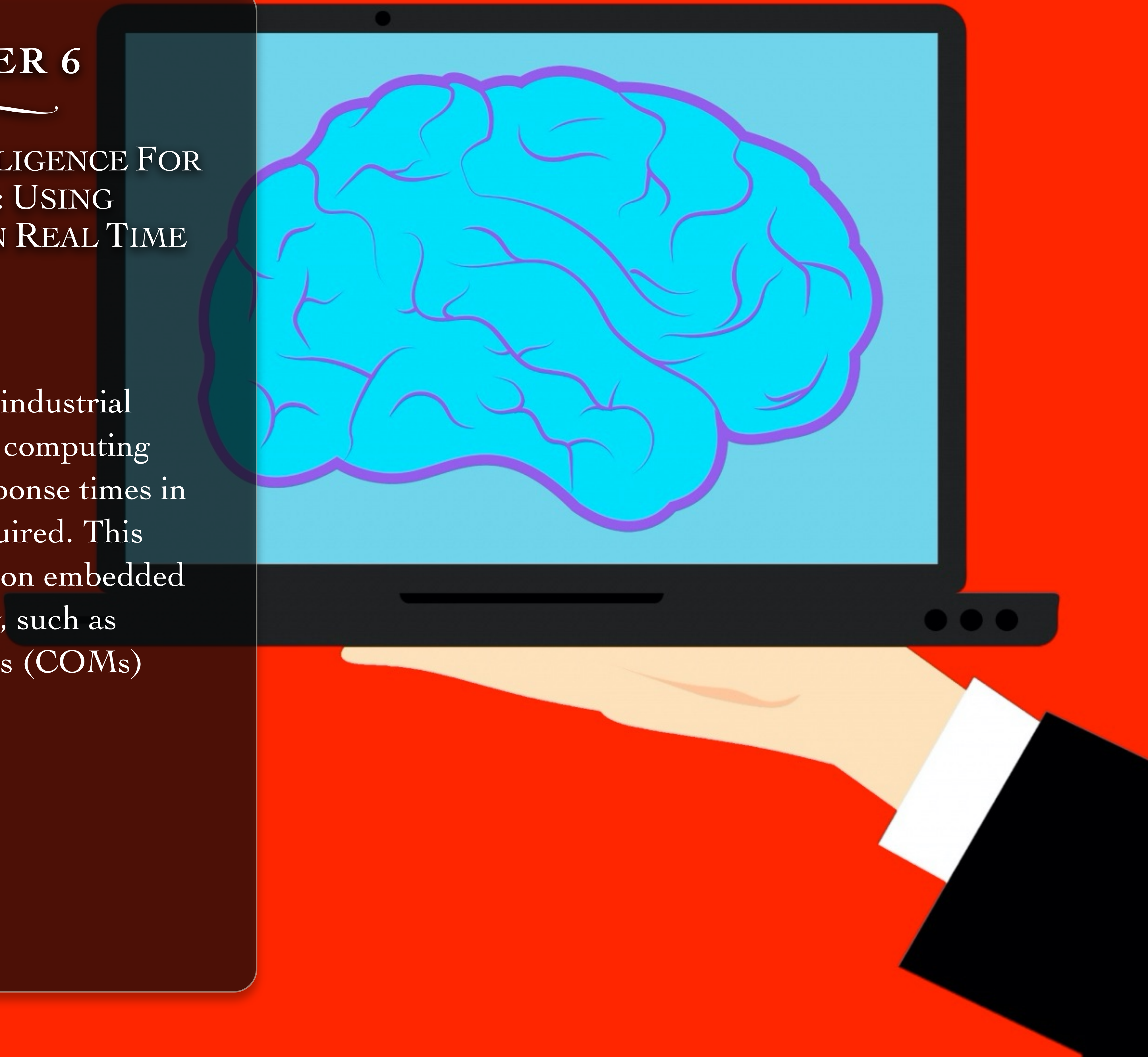
We, as an industry, need to do to accelerate time to market, reduce costs, raise quality, lower energy consumption and increase customization. Consider technologies that manage themselves, where smart products can take remedial action to evade damages and where individual parts are automatically replenished.


ARTIFICIAL
INTELLIGENCE

CHAPTER 6

Artificial Intelligence For Industries: Using Intelligence In Real Time

If AI is to be used in industrial applications, parallel computing with the shortest response times in real time is often required. This places new demands on embedded computer technology, such as computer-on-modules (COMs)



Artificial Intelligence For Industries: Using Intelligence In Real Time

By Zeljko Loncaric

The artificial intelligence (AI) market is currently experiencing an incredible boom. According to ResearchAndMarkets, the global AI market is expected to grow by 36.6 per cent annually to US$ 190.61 billion by 2025. AI is already all around us today. In our personal lives we experience AI, for example, in product, film and music recommendations as well as service hotlines, where AI bots answer general customer questions completely autonomously.

AI is also behind smartphone features, such as face and gesture recognition and personal (voice) assistants. However, according to Deloitte's study "Exponential Technologies in Manufacturing," one of the most important drivers for new AI is also the production sector.

Next to less-critical use cases—such as AI for predictive maintenance or demand forecasting—industrial AI can also be used in areas of application that require real-time capabilities. These include, for example:

- Industrial image processing, where AI helps capture many different states and/or product features, and evaluates these via intelligent pattern recognition to enable more reliable quality control. Forbes states that AI can increase error detection rate by up to 90 per cent.
- Cooperative and collaborative robots that share the same work space with humans can react flexibly to unforeseen events, making decisions based on situational awareness.
- Similar requirements apply to autonomous industrial vehicles.
- AI applications in the semiconductor industry showed, for example, 30 per cent reduction in reject rates when using Big Data to analyse root-cause data, which must be collected with high precision and in real time.
- Lastly, there is the large area of real-time production planning and control of Industry 4.0 factories. Here, AI helps optimise the processes at the edge, thereby

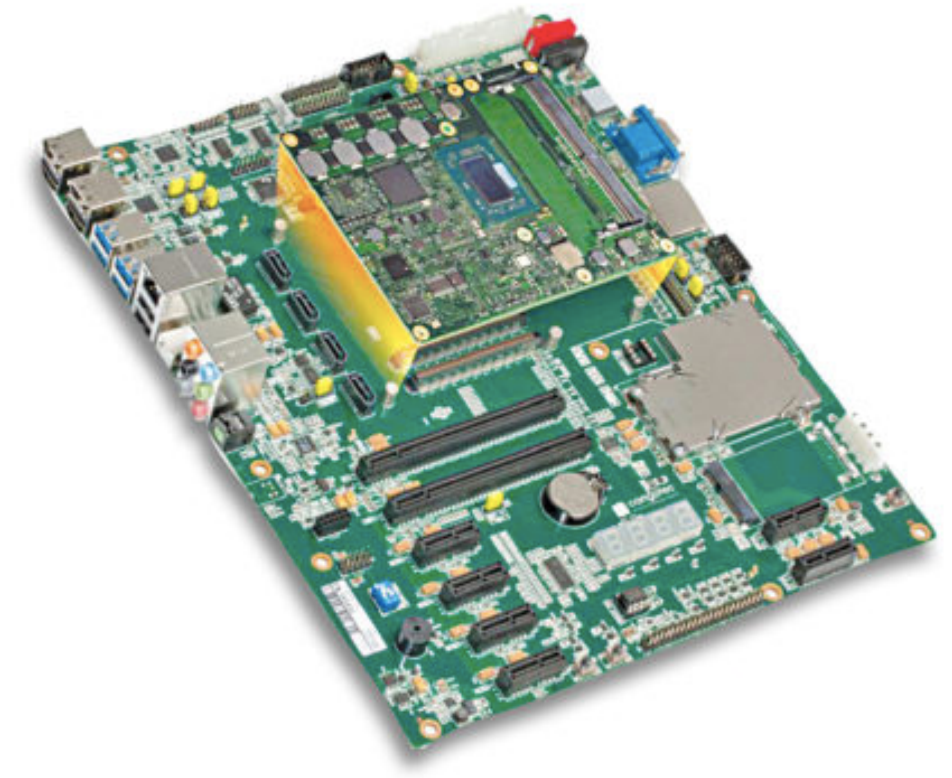


Fig. 1: Migration to AI is a simple task with COMs, as existing COM designs can easily be replaced with other processor technologies (Credit: congatec)

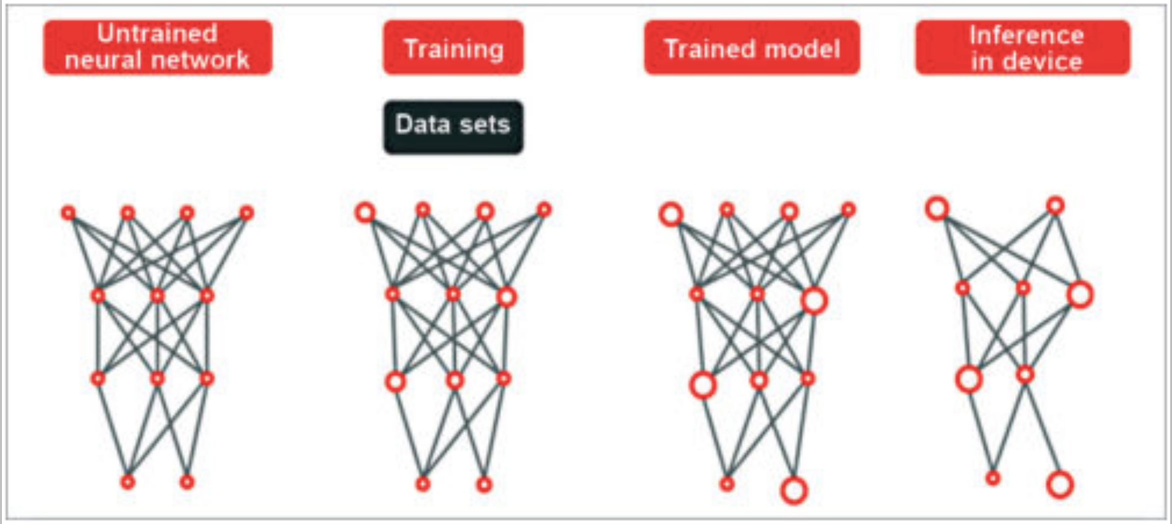


Fig. 2: Schematic illustrating deep learning in data centre/intelligence in the local industrial device (Credit: congatec)

increasing utilisation of machines and, ultimately, productivity of the entire factory.

Use of AI in industrial environments requires highly-advanced integrated logic. This is because, in fast processes—as in the case of inspection systems—there is often no further control authority. This is different, for example, in medical technology, where AI results of automatic image analysis are always controlled by a doctor and where AI's job is simply to make recommendations, accelerating data evaluation steps in the process.

For this reason, AI systems for use in industrial environments must always ensure that AI decision-making processes are traceable and—as regards machine and occupational safety requirements—100 per cent correct.

Training the AI is therefore much more complex in an industrial environment. There are also hardly any negative examples. This aspect, too, is different from medical technology, where thousands of negative and positive diagnoses can be used to train and teach systems.

In industry, on the other hand, errors must be avoided right from the start. This is why digital twins, that is, digital images of machines and systems, are often used here to simulate negative findings and then, for instance, rule out certain robot movements from the outset. So how do you develop and execute faultless industrial AI solutions for real-time requirements?

Bringing AI to the factory

To get a better understanding, a look at the basics of modern AI systems is helpful. First, it is necessary to distinguish between machine learning (where knowledge is constantly expanded with new clear information) and deep learning (where systems train themselves using large amounts of data and independently interpret new information). The procedure for the latter, that is, deep learning, is almost always identical, even for the most diverse tasks.

Many computing units—usually general-purpose graphics units (GPGPUs)—are combined to form a deep neural network (DNN). This deep learning network must then be trained. In the field of image processing, for example, pictures of various trees can be used to train the system. The amount of image data required is immense. Real-life research projects speak of 130,000 to 700,000 images. Using all this information, neural networks then develop parameters and routines based on case-specific algorithms to reliably identify a tree.

GPGPU: an important technology for AI

In most systems, the main pattern recognition work is done in the GPGPU-based cloud with its immense parallel computing power. However, in the manufacturing industry this is—at least for the time being—ground for exclusion, as processes are generally fast. Here, it must be ensured that

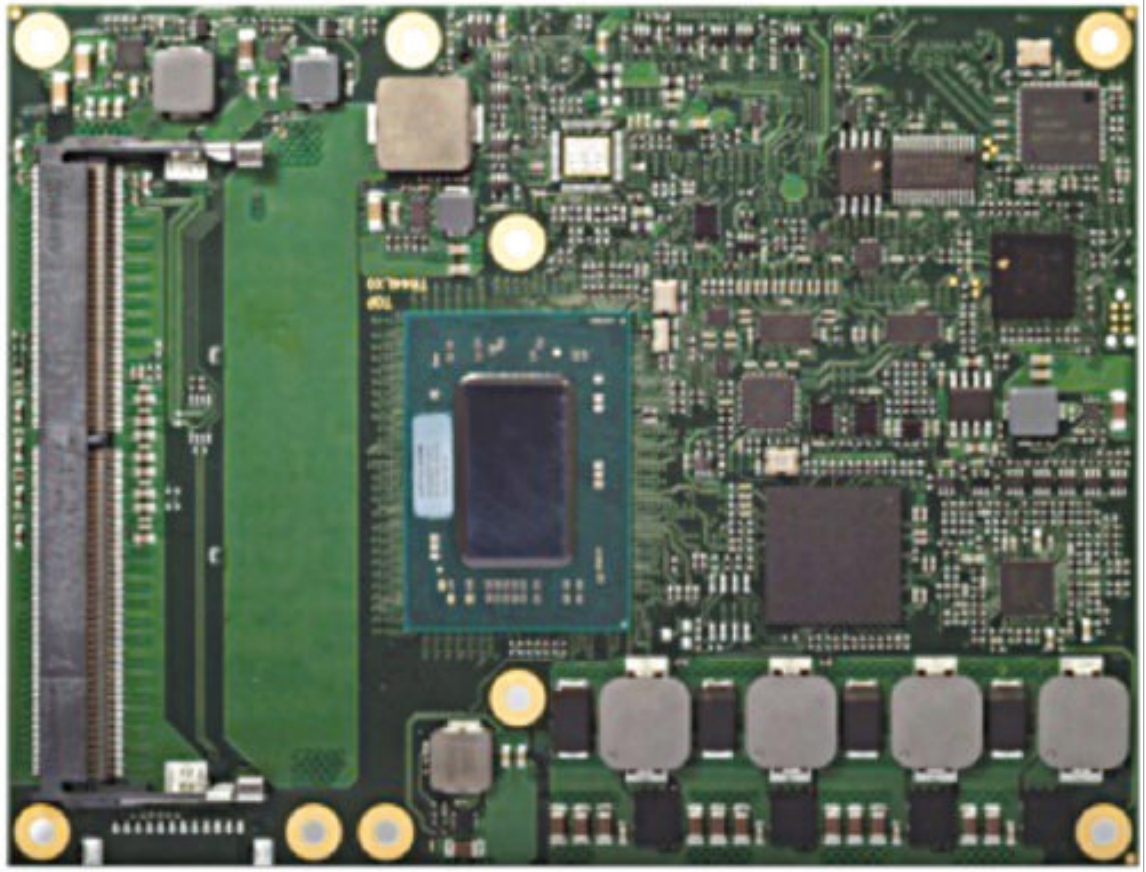


Fig. 3: conga-TR4 with AMD Embedded Ryzen processor (Credit: congatec)

intelligence resides at the edge, that is, in the immediate vicinity of or even within the device itself.

This is why industrial devices, machines and systems are mostly equipped with AI systems that use knowledge-based intelligence for real-time applications and pass data for deep learning on to central clouds that cannot be connected in real time yet. This means, it is possible today to keep training a higher-level system with all new data and to keep local devices up to date with regular software updates, so that such systems already classify as self-learning systems.

Only, in this case, learning does not follow a curve but takes place in cyclical steps. This is also a reason why issues such as digital twins or industrial edge servers are so important. If you can provide both, even deep learning can become increasingly real-time capable.

The right embedded processors

It does not matter which setup OEMs choose for their AI. The required, often massive, parallel-processing power for individual real-time capable machines or systems is nevertheless very high, even when using ordinary, purely knowledge-based AI. Latest embedded accelerated processing units (APUs) from companies like AMD support this need, as they offer a powerful GPU in addition to the classic x86 processor, whose general-purpose functions also support parallel AI computing processes, such as those used in data centres.

Using discrete embedded GPUs from the same manufacturer, this can be scaled further, making it possible to adapt open parallel computing performance to the precise requirements of the industrial AI application.

AMD Ryzen Embedded V1000. With significantly increased computing and graphics performance, the ultra-low power and industrially-robust AMD Ryzen Embedded V1000 series is a good choice. With a total of 3.6 TFLOPs from a multipurpose CPU and powerful GPGPU combined, it offers flexible computing power that until a few years ago was only achievable with systems that consumed several hundred watts.

Today, this computing power is already available from 15 watts. This makes the processors also suitable for integration

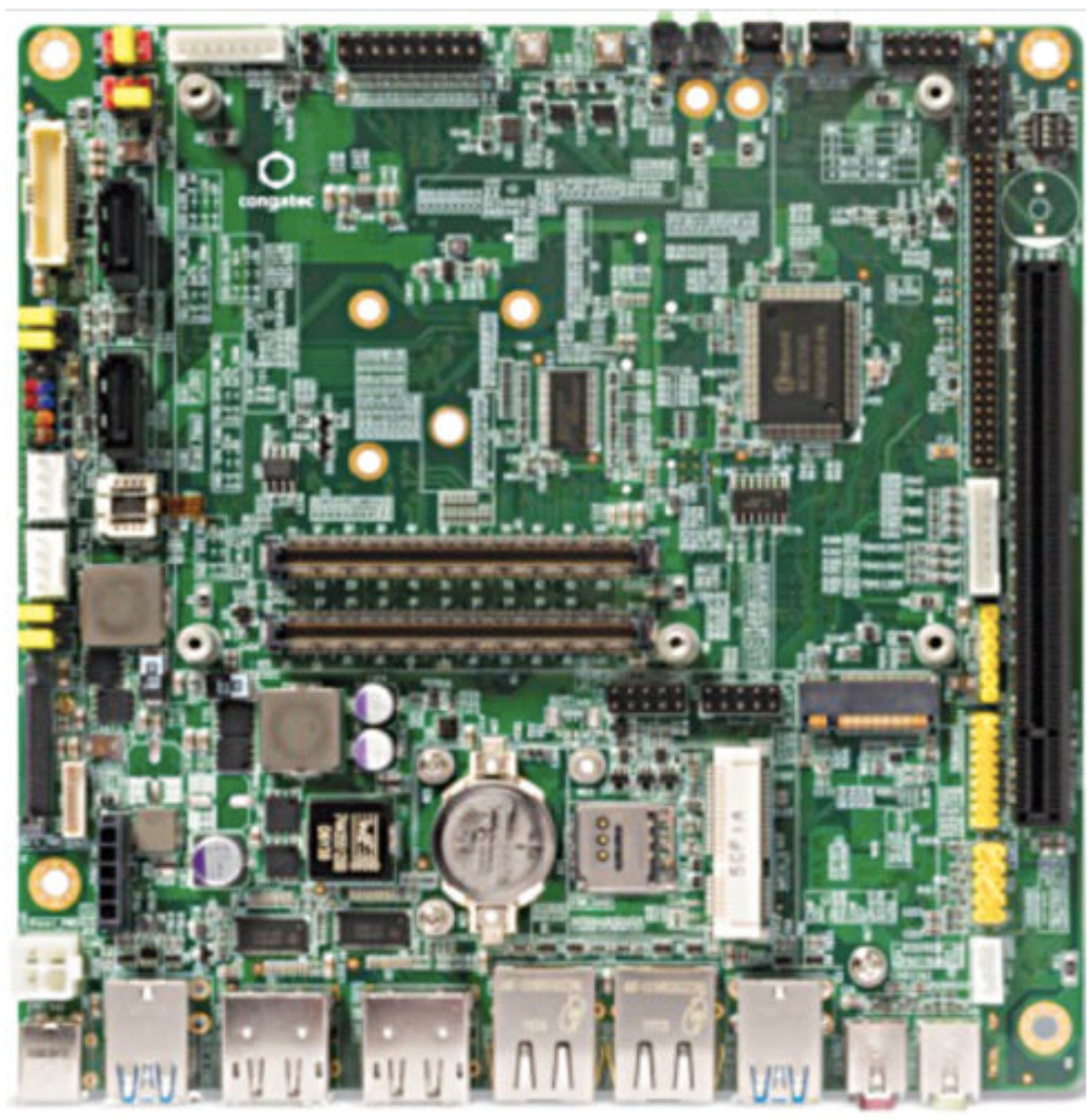


Fig. 4: conga-IT6 Mini-ITX motherboard (Credit: congatec)

in fan-less, completely enclosed and, hence, highly-robust devices for factory use. As real-time processors, these also

support memory with error correction code (ECC), which is essential for most industrial machines and systems.

As far as necessary software environment for fast and effective introduction of AI and deep learning is concerned, AMD embedded processors offer comprehensive support for tools and frameworks, such as TensorFlow, Caffe and Keras. At gpuopen, a wide range of software tools and programming environments for deep learning and AI applications are available. These include popular open source platform ROCm for GPGPU applications.

The open source idea is particularly important in this context, as it prevents OEMs from becoming dependent on a proprietary solution. HIPfy is an available tool with which proprietary applications can be transferred into portable HIP C++ applications, so that dangerous dependence on individual GPU manufacturers can be effectively avoided.

AI development has also become much easier with the availability of OpenCL 2.2, because since then, OpenCL C++ kernel language has been integrated into OpenCL, which makes writing parallel programs much easier. With such an ecosystem, both knowledge-based AI and deep learning are comparatively easy to implement, and are no longer just the reserve of billion-dollar IT giants like Google, Apple, Microsoft and Facebook.

Fast design-in with COMs

Now the only remaining question is: How can OEMs design these hardware-based AI enablers into their applications as quickly and efficiently as possible? One of the most efficient ways is via standardised computer-on-modules (COMs) that have been equipped with comprehensive support for GPGPU processing.

COMs have a slim footprint, support designs with OEM-specific feature sets, and as application-ready super components these come pre-integrated with everything that developers would otherwise have to arduously assemble in a full custom design. This makes COMs crucial for faster time-to-market.

As these are not only application-ready but also functionally-validated by many users, COMs offer high design security. This means that OEMs can expect to save between 50 and 90 per cent of their NRE costs when using modules. Thanks to the modular approach, the application can also be scaled to requirements. With a simple module swap, new performance classes can be integrated into existing carrier board designs without any further design effort, so that OEMs can easily add these innovative features to the functionality of their designs.

COM Express, the leading standard for high-end modules

A leading form factor among modules for this performance class is COM Express standard. This has been developed over many years by PICMG and is supported by all leading

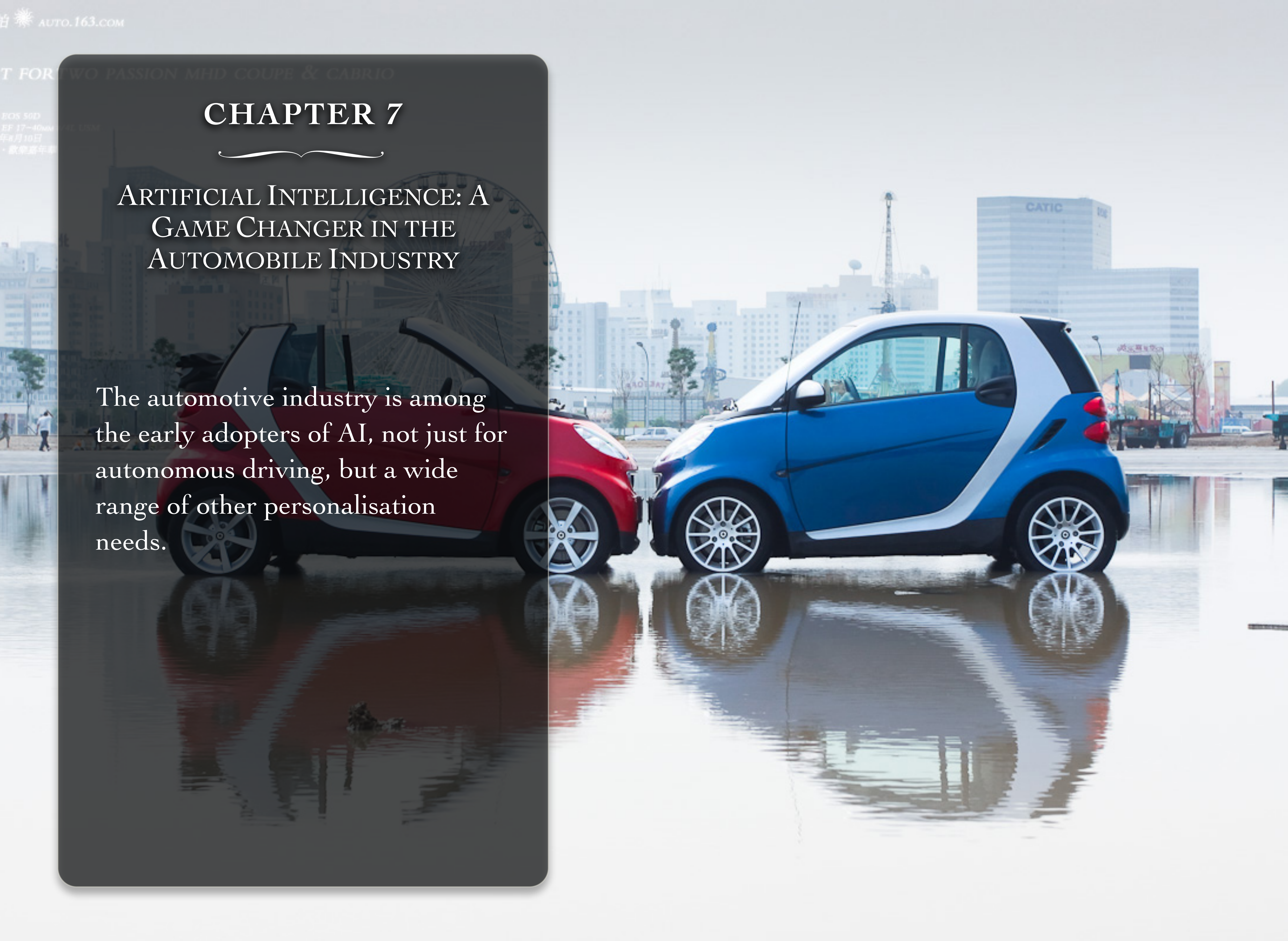
embedded computing suppliers. Companies like congatec—who have long been working closely with AMD and recently even extended the availability of AMD Geode processors—offer AMD Ryzen Embedded V1000 processor-based modules, for example, in COM Express Basic Type 6 form factor, which offers sufficient capacity to cover the entire performance range from 15 watts to 54 watts TDP.

Thanks to RTS hypervisor support, the real-time capable conga-TR4 module can also support AI platforms where deep learning systems and digital twins are to be connected via virtual machines so that hard real-time processing can always be ensured.

And with its standardised APIs, the module is also prepared for data exchange via the Internet of Things (IoT) gateways in compliance with SGET UIC standard. This allows OEMs to fully concentrate on developing the application—any missing glue logic can be specifically-developed and provided upon customer request.

Embedded high-end edge server design options

For OEMs wanting to bring their digital twins and deep learning intelligence to the industrial edge, there are many attractive options from companies like congatec. For example, embedded designs based on AMD EPYC Embedded 3000 processors come with long-term availability of up to 10 years. With up to 16 cores, 10-Gigabit Ethernet performance and up to 64 PCIe lanes, processors of the embedded server-class even enable deep learning applications at the edge of the Industrial IoT (IIoT). Hence, developers have everything they need on the hardware side for deep learning-based AI platforms for real-time industrial use.



CHAPTER 7

Artificial Intelligence: A Game Changer in the Automobile Industry

The automotive industry is among the early adopters of AI, not just for autonomous driving, but a wide range of other personalisation needs.

Artificial Intelligence: A Game Changer in the Automobile Industry

By Savaram Ravindra

Major players in the automobile industry are using technology and resources to be the best in the market. In lieu of the same, utilisation of artificial intelligence (AI) is also gaining great popularity over the years. AI attempts to learn from sensory inputs like real images and sounds, giving the technology the unique selling point for devices embedded with it. When intelligence is applied to an automobile, it recognises the environment and assesses the contextual implications during movement or when it faces any hurdles.

In vehicles, install rate of systems based on AI was only eight per cent in 2015. This number is expected to go up exponentially by 2025.

AI driving autonomous cars

Since the 1970s, people have been thinking about driverless cars. Over the years, AI-enabled cars have been shown in movies and captured our imagination. But lack of resources and technical brilliance have kept these from becoming a reality.

The scenario is different today, and self-driving cars have become a reality. We are on our way to witness real intelligence in cars. The aim is to make vehicles act like drivers. However, the major challenge faced by automobile makers is understanding how a car understands different situations and functions accordingly. This task requires a high amount of computing.

Using techniques like deep learning (DL) and sensor fusion, researchers have built a technology that can develop a 3D map of all activities that happen around a car. Leading automotive and tech giants like Tesla and Google are spending large amounts of money for the development of innovative technologies and, thereby, making autonomous cars a commercial reality.

Let us look at why AI is a game changer in the automobile industry.

Machine learning

AI is intelligence developed as a result of many scientific experiments. When applied to machines and devices, this intelligence thinks and acts like humans.

However, there is a difference between machine learning (ML) and AI. While the latter implies that devices execute tasks that are considered smart by humans, the former refers to the application of the latter where machines are provided with certain data and these learn for themselves. In essence, ML can be considered a sub-set of AI. Toyota has brought together AI, ML and Big Data for the generation of highly responsive autonomous systems, which can help people who cannot drive properly.

Deep learning

ML is implemented using DL. Many activities in AI are carried out using DL. Complex tasks are broken down into smaller ones, which then become manageable. Software in DL learns activities and mimics these in the brain's neuron layers.

Today, DL techniques play a vital role in autonomous driving and advanced driver assistance systems—what goes on inside the vehicle. DL plays a major role in the workings of the outside of the vehicle, and during service, sales and manufacturing phases.

Continuous improvements are being made in the service phase using DL. A partnership has been formed between Bosch and NVIDIA to enhance the features and quality of autonomous vehicles. As part of this partnership, Bosch will develop a supercomputer that works in autonomous vehicles and DL will offer technology to power it. A new level of AI in cars such as Mercedes Benz and Audi is expected in the future, thanks to Bosch and NVIDIA.

The Internet of Things

In the automobile industry, the Internet of Things (IoT) has made an indelible mark. It is poised to become even more powerful in the years to come. Vehicles now come with a host of features, like embedded connectivity applications, geo-analytic capabilities using Big Data and smart sensors.

Vehicle owners now enjoy many attributes, as given below:

- A manufacturer or dealer can share firmware updates of a vehicle via over-the-air software.
- A vehicle's performance data can be sent to the service centre, dealer and manufacturer if it is scheduled for repair or service on a specific day.
- Organisations with a large number of vehicles can handle the same using enhanced safety parameters.
- Through IoT processes, improved quality in manufacturing is possible.
- Smart sensors in a car can alert relevant medical personnel in case of an emergency.

Cognitive capabilities

Cognitive analysis imitates the behaviour of the brain by looking at its data mining capabilities and behaviour

patterns. This revolutionises not only small cars with AI capabilities but also large, 18-wheel carrier trucks.

Cognitive systems need to have a much deeper understanding of unstructured data, as these must work like a human would in a real-life situation. To decide on how to respond naturally in real time, many insights are drawn from large amounts of unstructured data.

Dynamic operating conditions can also be handled by cognitive capabilities. These capabilities are already being incorporated into vehicles by many car manufacturers. For example, to add cognitive capabilities to its cars, BMW has entered into a partnership with IBM.

Infotainment systems

AI transforms in-vehicle infotainment systems in a significant manner. Demand for high-quality software and hardware solutions has soared due to this, as these have to be compatible with AI.

We can expect a spike in features such as natural languages database, gesture recognition, driving pattern monitoring, eye tracking and speech recognition. This will eventually go a step further to detection units based on radars, sensor fusion engine control units, camera-attached machine vision systems and evaluation of driver condition.

Machine-human interfaces attached to vehicles can monitor and act in accordance with algorithms collected from neural networks based on cloud. These are utilised to perform a number of advanced tasks.

Conclusion

We will soon witness the cloud-to-air phenomenon (a new kind of car driving) through AI capabilities. Developers have created applications that have taken AI to a new level of excellence, thanks to great computational power.

AI is not only about self-driving cars. It also helps in developing cars that can perceive the environment and navigate through hindrances that may come up while driving.

CHAPTER 8

Sensors for Robotics and Artificial Intelligence

Just like sense organs play an important role in the human body, electronic sensors play a vital role in robotics and artificial intelligence.



Sensors for Robotics and Artificial Intelligence

New and advanced technologies have recreated most human sense organs, or sensors, in robots including eyes, ears, skin and nose. Just like sense organs play an important role in the human body, electronic sensors play a vital role in robotics and artificial intelligence (AI).

Robotics and AI serve different purposes. Robotics involves building robots, whereas AI deals with programming intelligence or making computers behave like humans.

Accordingly, the context of sensors in robotics and AI may be slightly different. Robots are programmable machines, interact with the physical world via sensors and actuators, and can be made to work autonomously or semi-autonomously. However, many robots have limited functionalities and are not artificially intelligent. Some industrial robots can only be programmed to perform a repetitive task, which does not require AI. Some AI algorithms are often required to allow the robots to perform more complex tasks.

Human-like operations of machines induced by AI include speech recognition, planning, problem solving and learning, among other tasks. Not all AI algorithms are used to control robots. For example, AI algorithms are used in virtual assistants like Google Assistant, Amazon Alexa and Apple Siri.

When robotics and AI are combined, we get artificially-intelligent robots. However, without sensors, AI robots are blind, deaf and dumb. Machine perception, learning, speech recognition and the like are achieved through sensory inputs such as cameras, microphones, wireless signals, active lidar, sonar and radar to deduce the different aspects of the world (including facial, object and gesture recognition).

Modern technology for AI robots can be a blessing or a disaster for human beings, at the same time. For example, a killer robot based on AI could be a very dangerous thing. There has been a huge campaign by AI experts all over the world to boycott killer robots reported to be under-development at Korea Advanced Institute of Science and Technology (KAIST). However, KAIST's president, Sung-Chul Shin, has denied any such development.



Fig. 1: Campaign to stop killer robots (Credit: www.theguardian.com)

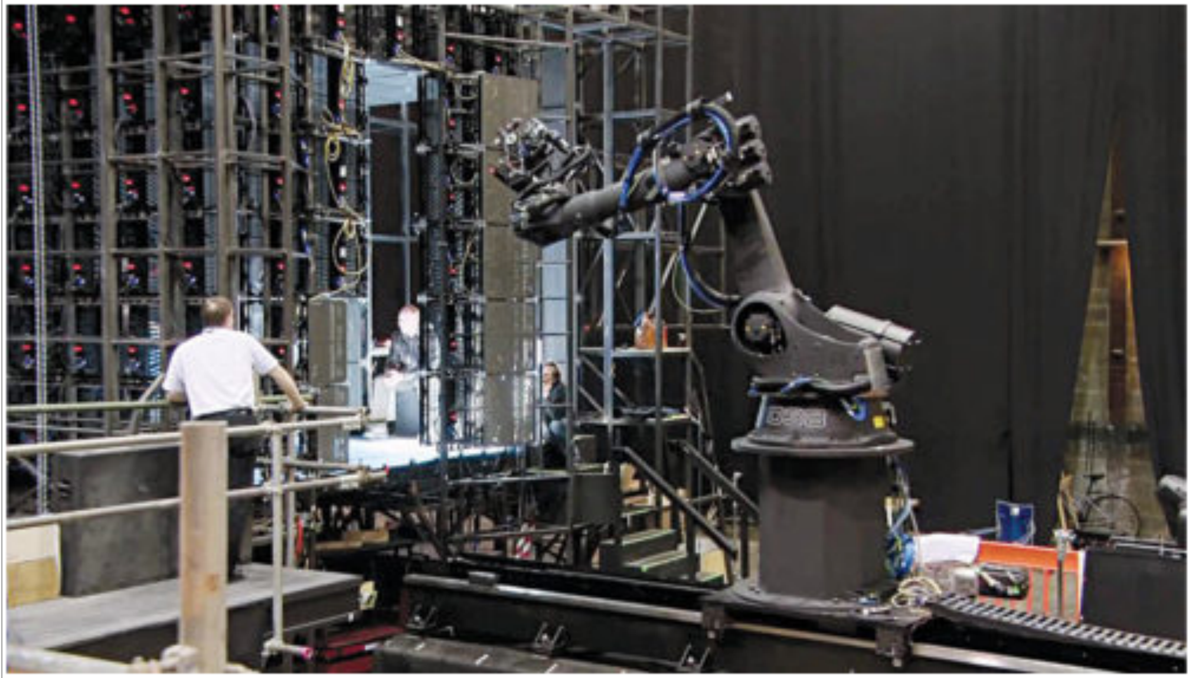


Fig. 2: Robotic arm used while shooting Gravity, a science fiction thriller (Credit: www.derivative.ca)

Robots are not only used for educational, industrial, military and civil applications, but also in movies and entertainment industry. Gravity, a science fiction thriller, used robots that were originally designed for performing assembly, welding and painting applications. The robotic arm driven by sensors was made to carry cameras, lights, props and even actors. By using the robotic arm behind the scenes, the director was able to achieve remarkable shots for the movie.

Then, there are robots such as QRIO and RoboSapien that are capable of advanced features like voice recognition or walking.

Sensors and robotics

A typical robot has a movable physical structure driven by motors, sensor circuitry, power supply and computer that controls these elements.

Some popularly known robots are:

- Educational robots are mostly robotic arms used to lift small objects, or wheels to move forwards, backwards, left or right, with some other features.
- Honda's ASIMO robot can walk on two legs like a person.
- Industrial robots are automated machines that work on assembly lines.
- BattleBots are remote-controlled fighters.

- DRDO's Daksh is a battery-operated, remote-controlled robot on wheels. Its primary role is to recover bombs.
- Robomow is a lawn-mowing robot.
- MindStorms are programmable robots based on Lego building blocks.

Some robots only have motorised wheels, while others have dozens of movable parts, including spin wheels and pivot-jointed segments with some sort of actuators. Some robots use electric motors and solenoids as actuators, while others use a hydraulic or a pneumatic system. Most autonomous robots have sensors that can move and perform a specific task without human intervention or control.

One interesting technology under development in the field of robotics is the micro-robot for biological environment. A micro-robot may be integrated with sensors, signal processing, memory unit and feedback system working at a micro-scale level. This development can have important implications for integrated micro-bio-robotic systems for applications in biological engineering and research.

Some common robotic sensors are given in the table.

Biosensors

Biosensors use a living organism or biological molecules, especially enzymes or antibodies, to detect the presence of chemicals. Examples include blood glucose monitors, electronic noses and DNA biosensors.

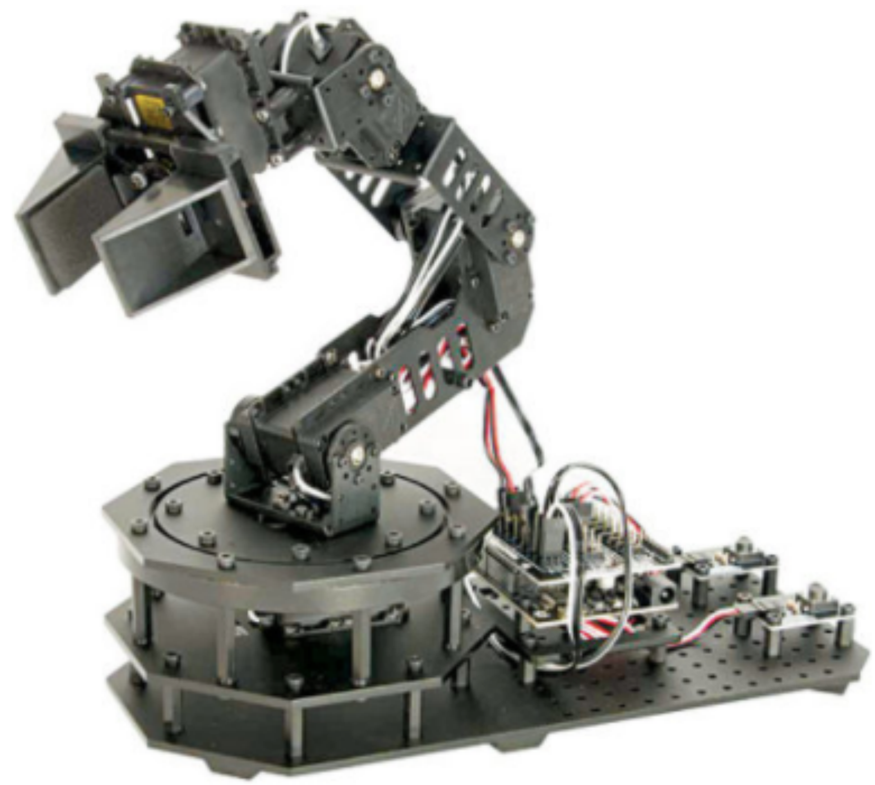


Fig. 3: Arduino-based robotic arm (Credit: www.trossenrobotics.com)

COMMON SENSORS USED IN ROBOTS

Sensors	Functions
Touch	Sensing an object's presence or absence
Force	Measuring force along a single axis
Vision	Detecting edges, holes and corners
Proximity	Non-contact detection of an object
Physical orientation	Co-ordinates of objects in space
Heat	Wavelength of infrared (IR) or ultra violet (UV) rays, temperature, magnitude and direction
Chemicals	Presence, identity and concentration of chemicals or reactants
Light	Presence, colour and intensity of light
Sound	Presence, frequency and intensity of sound

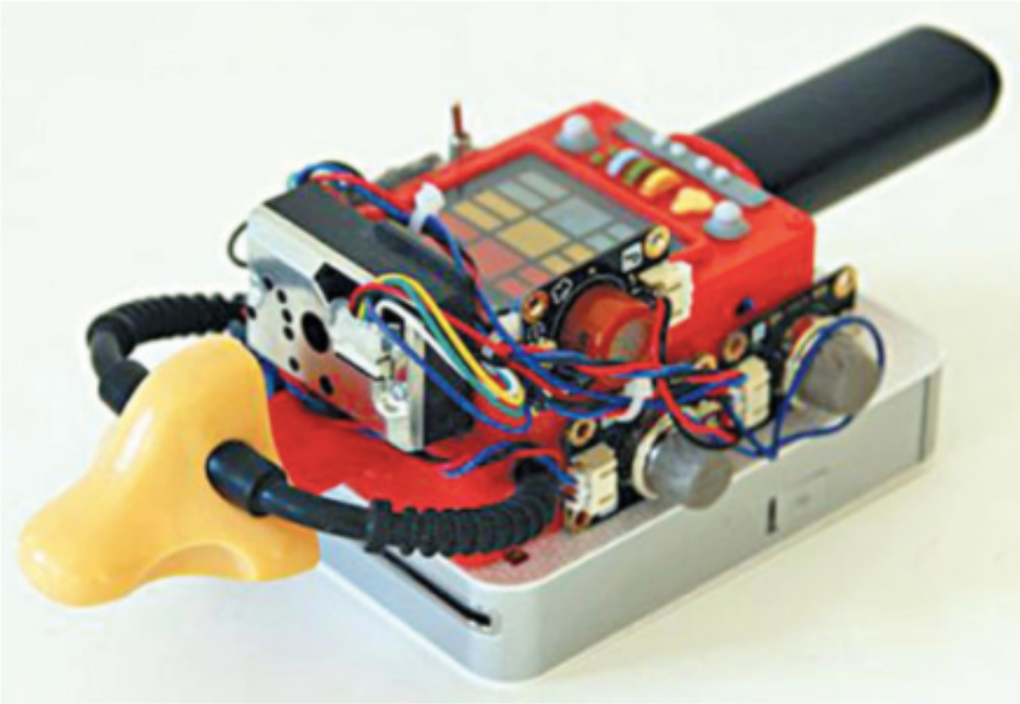


Fig. 4: Electronic nose module (Credit: https://blog.arduino.cc)

Raindrops sensors

These sensors are used to detect rain and weather conditions, and convert the same into number of reference signals and analogue output.

Multi-axis force torque sensors

Such sensors are fitted onto the wrist of robots to detect forces and torques that are applied to the tool.

Optoelectronic torque sensors

These sensors are used for collaborative robot applications, ensuring safer and more effective human-machine-collaboration. These have less than one microvolt of noise even in low-torque range, can self-calibrate and measure to an accuracy of 0.01 per cent. A contactless measurement



Fig. 5: Raindrop sensor (Credit: http://wiki.bernardino.org)

principle ensures that the sensors are insensitive to vibration and are wear resistant.

Inertial sensors

Motion sensing using MEMS inertial sensors is applied to a wide range of consumer products including computers, cell phones, digital cameras, gaming and robotics. There are

various types of inertial sensors depending on applications. LORD MicroStrain manufactures industrial-grade inertial sensors that provide a wide range of tri-axial inertial measurements, and computed attitude and navigation solutions.

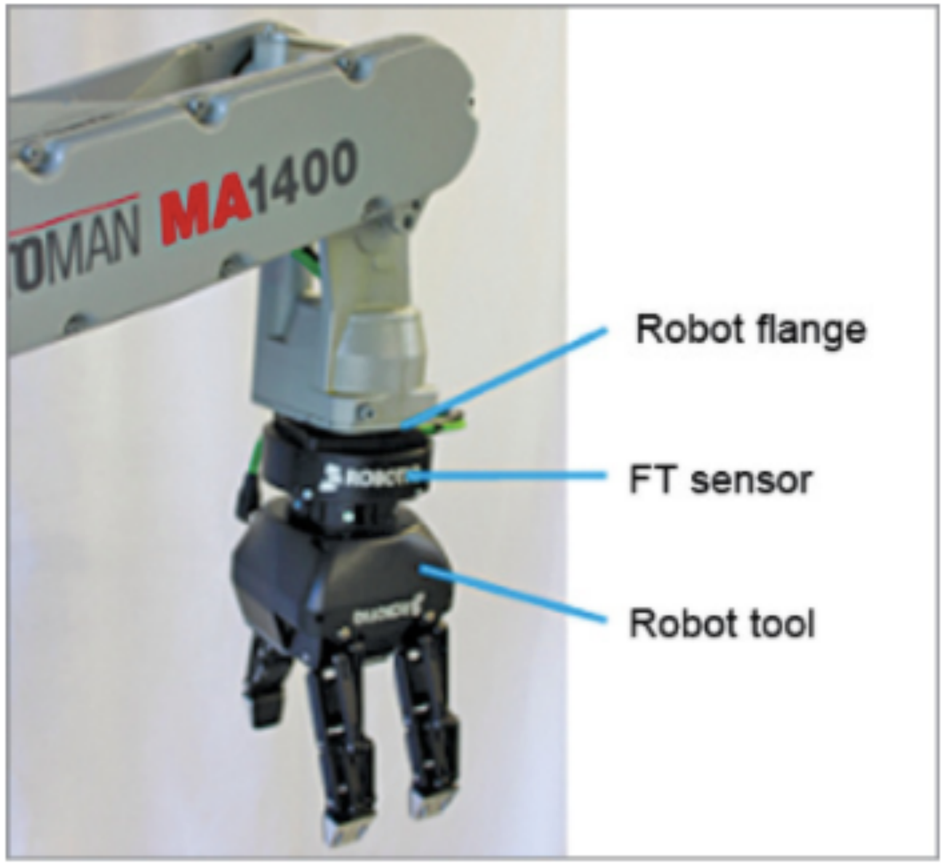


Fig. 6: 6-axis force torque sensor fitted onto robotic arm (Credit: https://blog.robotiq.com)

Sound sensors

Sound sensors are used in robots to receive voice commands. High-sensitivity microphones or sound sensors are essential in voice assistants like Google Assistant, Alexa and Siri.



Fig. 7: Optoelectronic torque sensor (Credit: www.dpaonthenet.net)

Emotion sensors

Robots can react to human facial expressions using emotion sensors. B5T HVC face-detection sensor module from Omron Electronics is a fully-integrated human vision component (HVC) plug-in module that can identify faces

with speed and accuracy. The module can evaluate the emotional mood based on one of the five programmed expressions.

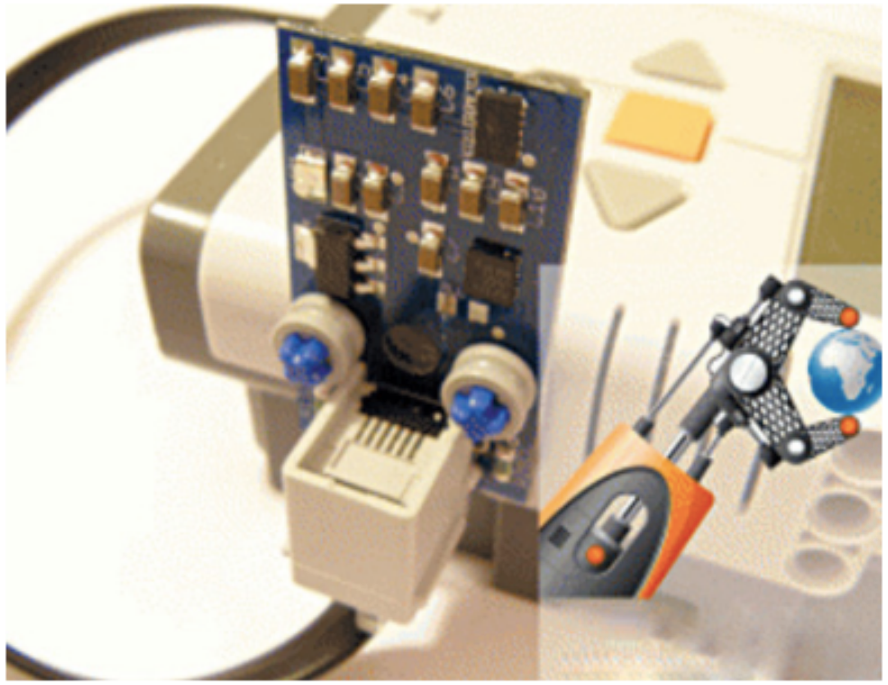


Fig. 8: Inertial sensor mounted on robot (Credit: www.dexterindustries.com)



Fig. 9: High-sensitivity sound sensor (Credit: http://fut-electronic.com)

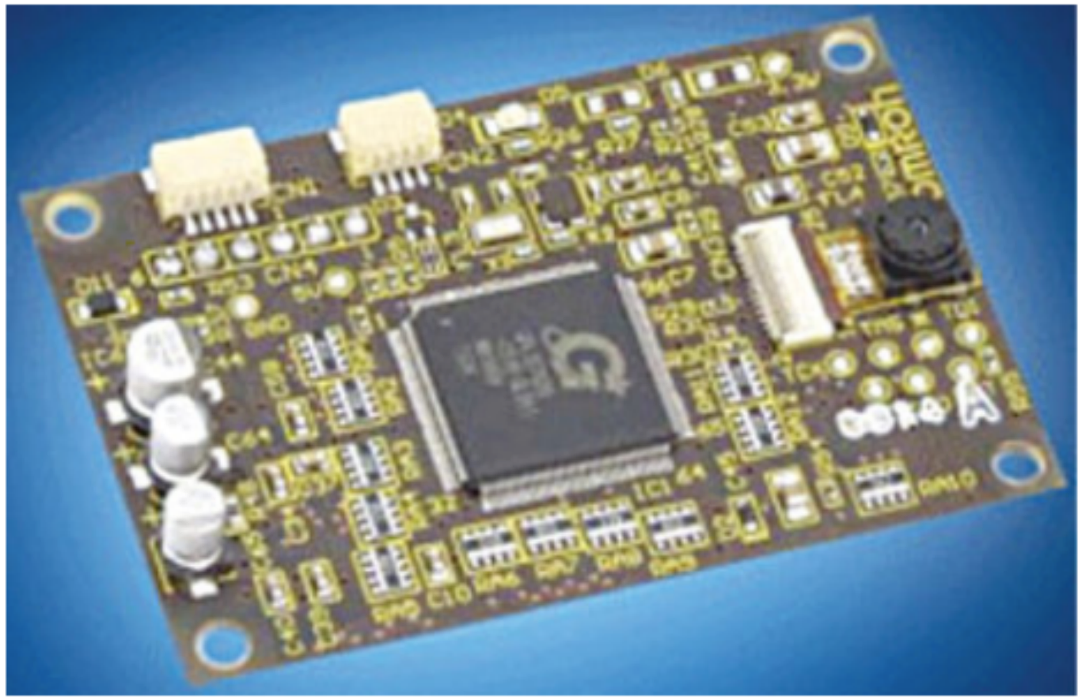


Fig. 10: B5T HVC face-detection sensor module (Credit: www.mouser.com)

Grip sensors

RoboTouch Twendy-One gripper features embedded digital output, which is ideal for OEM integration into a gripper. These sensors comprise multiple sensing pads, each having multiple sensing elements. Data from



Fig. 11: RoboTouch Twendy-One gripper (Credit: https://pressureprofile.com)

sensors is transferred to grippers via I2C or SPI digital interfaces, enabling easy integration of the sensors into grippers.

Artificial intelligence

Sensors used in AI robots are the same as, or are similar to, those used in other robots. Fully-functional human robots with AI algorithms require numerous sensors to simulate a variety of human and beyond-human capabilities. Sensors provide the ability to see, hear, touch and move like humans. These provide environmental feedback regarding surroundings and terrain.

Some leading manufacturers of sensors for robotics

- Analog Devices
- Dexter Industries
- LORD MicroStrain
- Murata
- Omron
- Pressure Profile Systems Inc.
- Rockwell Automation
- Seeed Technology Co. Ltd
- Siemens
- Tamagawa Seiki

Distance, object detection, vision and proximity sensors are required for self-driving vehicles. These include camera, IR, sonar, ultrasound, radar and lidar.

A combination of various sensors allows an AI robot to determine size, identify an object and determine its distance.

Radio-frequency identification (RFID) are wireless sensor devices that provide identification codes and other information.



Fig. 12: Atlas humanoid robot (Credit: https://en.wikipedia.org)

Force sensors provide the ability to pick up objects.

Torque sensors can measure and control rotational forces.

Temperature sensors are used to determine temperature and avoid potentially-harmful heat sources from the surroundings.

Microphones are acoustical sensors that help the robot receive voice commands and detect sound from the environment. Some AI

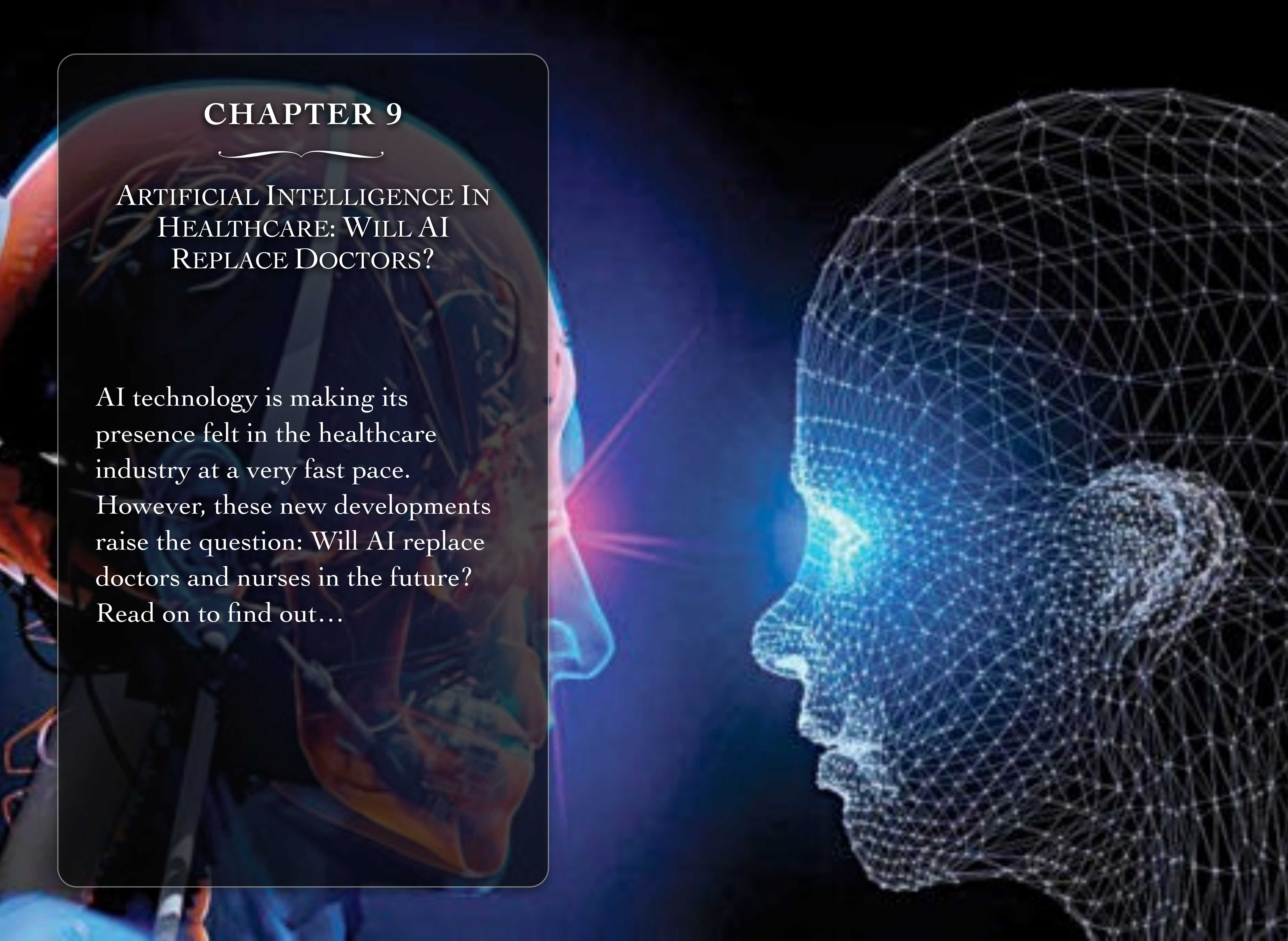
algorithms can even allow the robot to interpret the emotions of the speaker.

Humanoid robots with AI algorithms can be useful for future distant space exploration missions. Atlas is a 183cm (6-feet) tall, bipedal humanoid robot, designed for a variety of search-and-rescue tasks for outdoor, rough terrains. It has an articulated sensor head that includes stereo cameras and a laser range finder.

To sum up

The right use of sensors can improve the performance of artificially-intelligent robots. Getting raw sensor data alone is not enough. AI tools can be useful when applied to sensor systems. Many new sensors are being developed, and the use of hybrid tools can further improve the strengths of AI robots.

New advances in machine intelligence are creating seamless interactions between people and digital sensor systems. AI has powerful tools for use along with sensor systems, for automatically solving problems that would normally require human intelligence. These are knowledge-based systems, fuzzy logic, learning, neural networks, reasoning and ambient intelligence.



CHAPTER 9

Artificial Intelligence In Healthcare: Will AI Replace Doctors?

AI technology is making its presence felt in the healthcare industry at a very fast pace. However, these new developments raise the question: Will AI replace doctors and nurses in the future? Read on to find out…

Artificial Intelligence In Healthcare: Will AI Replace Doctors?

By Sani Theo

The intellectual prowess of humans and technological advancements in the 21st century can cause excitement, worry and fear at the same time. We have come across many science fiction stories and movies, some of which can be scary. These feature machines and robots taking control over humans, bringing the dead alive, communicating with intelligent beings in outer space and so on.

Artificial intelligence (AI) was once fiction but is now a reality. The quest for human longevity, and peace of mind and body through modern technology has resulted in many positive outcomes. Modern science and AI have brought in new ways to improve human existence, survival and achieve certain feats that were otherwise not possible. The pace of technological progress in genetics, 3D bioprinting, nanotechnology, medical imaging, voice recognition, biosensors and AI will become so fast that humans will undergo a radical evolution.

AI is part of the new frontier in the medical and healthcare industry. But with the proliferation of AI and its advantages in healthcare space, there are speculations that AI will someday replace human doctors in many areas. There are many proofs to support this statement, some of which are covered in this article.



Fig. 1: Vscan portable ultrasound device (Credit: www.gehealthcare.com)

AI winter or AI spring

AI is different from previous technological innovations because it can learn and is more intelligent. Earlier, there were setbacks and frustrations while pursuing AI programs —the term is called AI winter and it first appeared in 1984. But with recent progress in speech recognition, image processing and machine learning, AI has become an essential component of almost every field.

Modern technology has demonstrated many wonders in such areas as self-driving cars, autonomous drones, medicine and healthcare services. Use of AI and the Internet of Medical Things (IoMT) in healthcare is already helping many people.

Now, AI and machine learning are becoming hot topics. Andrew Ng, former director of Google's first AI group, Google Brain and former chief scientist of Baidu, believes that we have entered an eternal AI spring. This is because AI and machine learning have a wide range of applications and a clear roadmap for changing almost all industries. With AI, there are many wonders and surprises in store for us in the coming years. AI is limited only by our imagination!

Medical AI is so hot!

Tens of millions of people die each year from diseases that are treatable. Cancer treatment is not affordable by many. Now, AI is being employed in diagnosing cancer, tuberculosis, skin, eyes, stroke and other conditions, and it is more precise, accurate, faster and cheaper. AI is not only an industry-disrupting force but an important component that leads to affordability and accessibility for common people.

The current stethoscope could be a dumb thing in the future. For example, an Australian company has developed an AI-enabled electronic stethoscope called Stethee, which is far better than the current stethoscope. Stethee can be used as a regular stethoscope, in addition to being used to amplify, filter and record sounds, and to analyse sounds using an accompanying smartphone app.

An ultrasound machine is quite costly, but as technology progresses, its cost will come down and it will be affordable by individuals. There are promising signs of AI solutions in ultrasound imaging. For example, iQ probe with semiconductor chips, developed by Butterfly Network, can be used by patients to perform their own ultrasound tests. Understanding the results of an ultrasound can be hard for untrained patients, but iQ has an AI component in it. As AI gets smarter, risks-associated image interpretation will eventually reduce.

Portable ultrasound that can be accessed on the cloud and smartphones are now available in the market. Israel-based DiA Imaging Analysis, in partnership with GE Healthcare, has developed Vscan, a smartphone-sized ultrasound device. It also collaborates with Google Cloud to offer AI-powered automated ultrasound analysis for patient care, enabling quick analysis and easy accessibility anywhere, anytime.

There is concrete proof that AI is way better than a radiologist in detecting various parameters of the human body. A recent report showed that Google AI machine can tell vital body details including gender, heart conditions or other cardiovascular problems just by scanning the eyes.

In China, AI is being used to detect diseases that cause blindness. Researchers are using AI to support instant diagnosis of blindness and diabetes-related eye diseases in the earliest stages. Reports suggest that eye diseases can be treated faster with AI.

AI has had a strong impact on healthcare advancements due to its ability to analyse massive amounts of genomic data, leading to more accurate prevention and treatment of medical conditions on a personalised level. Use of AI robotic surgery has spread rapidly in recent years and, for certain types of operations, it has become the standard.

Imagine that a hospital full of AI-humanoid robots! A robotic doctor pulls your arms and legs to check your body condition; you may feel awkward or uncomfortable at the first instance. But that could be the scenario in the future.

AI and 3D bioprinting

3D bioprinting is the utilisation of 3D printing to print tissues and organs to help research drugs and pills. Researchers at a hospital in Boston have pioneered a 3D bioprinting technique that can create complex structures to replace damaged body tissues. This advanced technique could lead to a huge demand for bioprinting complex artificial tissues.
AI-powered medical imaging software developed by Aether has given a significant boost to 3D organ printing.

The thyroid gland printer from Russia-based 3D Bioprinting Solutions is shown in Fig. 2.

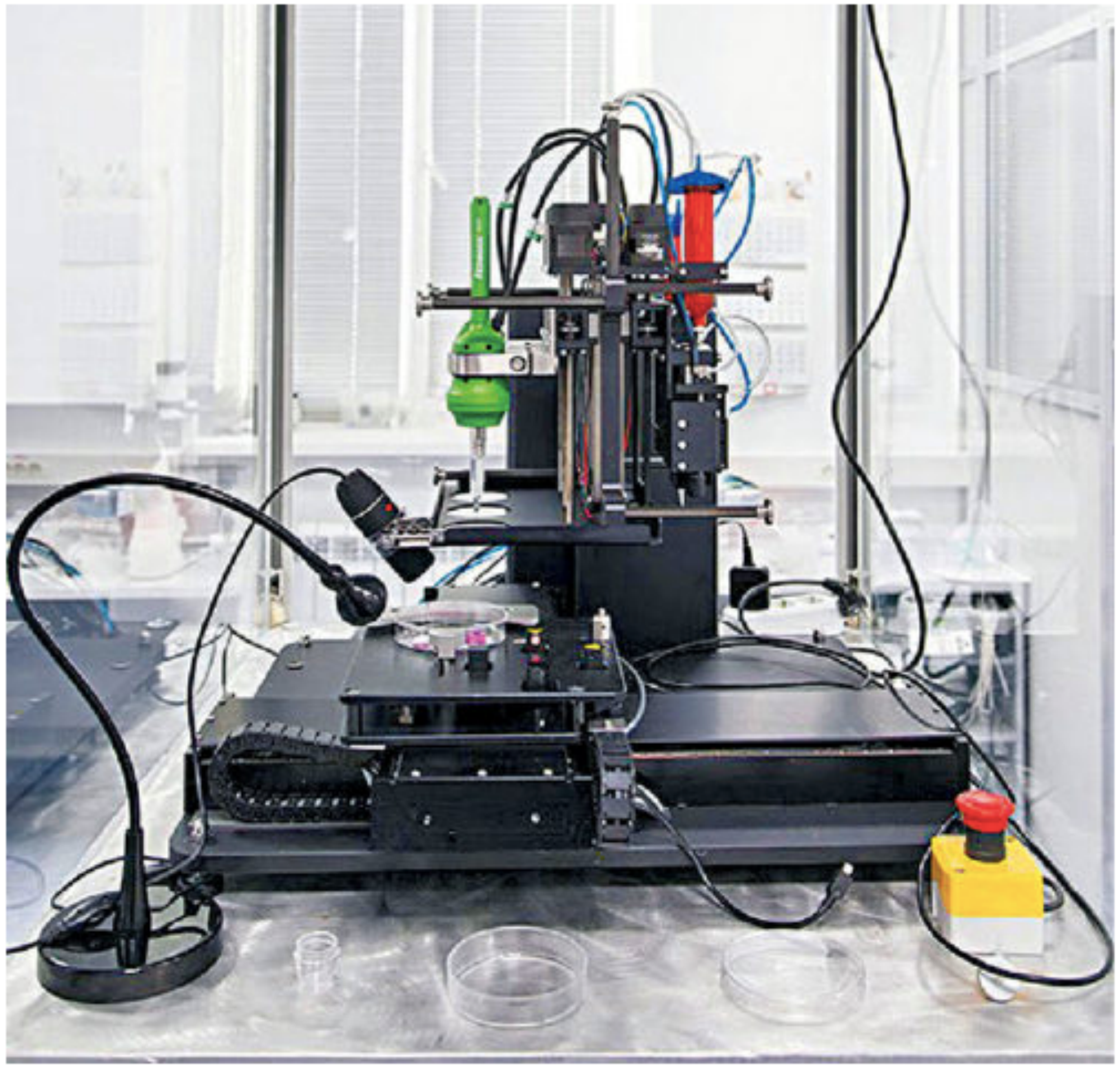


Fig. 2: Printer from Russia-based 3D Bioprinting Solutions (Credit: Wikipedia)

AI and DNA sequencing

Genome editing (or gene editing) is a type of genetic engineering. The worlds of genetics and AI are set to explode soon. With genetic engineering we can reprogram the basic building blocks of life—a reliable technique for making precise changes to an individual's DNA (deoxyribonucleic acid). For example, in the future, we may be able to eliminate autism from the human genome. With advances in AI applications, researchers will be able to interpret and act on genomic data much faster, more accurately and at a lower cost.

China is a huge power house of DNA sequencing. BGI-Shenzhen has emerged as a genomics superpower. It has agreed to collaborate to sequence the genomes of 5000 cassava varieties and 10,000 autism patients and family members, and carry out heaps of sequencing for the international Human Variome Project.

Nanotechnology, 3D bioprinting and AI can boost researches in these disciplines and provide a new generation of technologies that can have a huge positive impact on human lives and medical science. Many predict that genetic editing and the nanotech revolution aided by advanced AI could easily redesign and rebuild human bodies.

AI and healthcare in India

AI in the healthcare sector in India is extremely positive. With a large population in a country like India, there is a huge gap between skilled doctors and patients. AI is the right option to tackle such problems as an uneven doctor-to-patient ratio, untrained doctors and nurses for complex procedures, and no healthcare access to remote and rural areas.

The government of India is taking keen interest in the national strategy on AI and other emerging technologies. Its think-tank, NITI Aayog, has identified five such sectors, including healthcare, to focus its efforts towards implementation of AI. NITI Aayog is in partnership with Google for developing AI-based solutions to accelerate the future of machine learning and AI in India. The partnership will build AI-assisted models to detect diabetic retinopathy screening models that will help in early risk detection.

NITI Aayog has also signed a statement of intent with various companies, including ABB, IBM and SAP, related to AI projects. It is also collaborating with Intel and Tata Institute of Fundamental Research (TIFR) on various AI-based research projects.

There are many Indian startups in the field of AI-based healthcare including Lybrate, mfine, Artelus, ChironX, LiveHealth, OnliDoc and Qure.ai.

- Lybrate is an online doctor consultation platform that connects patients with doctors and provides online consultation. Patients can also book lab tests and appointments online.

- mfine provides a virtual doctor with the ability to diagnose and triage common diseases.
- It refers patients with serious conditions to a hospital. Its goal is to provide healthcare to every Indian, including those in remote areas, through its virtual platform and AI software.
- OnliDoc uses AI and machine learning for end-to-end medical diagnosis. It has a phone application (available on Apple Store and Google Play Store) that can be used to find doctors, book appointments, and store medical records and prescriptions.
- LiveHealth is a management information system (MIS) for healthcare providers. It collects samples, manages patient records, diagnoses patients and generates reports.

Will AI replace doctors?

Over the course of various industrial revolutions, horses were replaced by machines yet there were no complaints. But think of machines replacing humans. Human doctors can make errors and many patients die due to such errors. Doctors suffer from fatigue, personal problems and other priorities at times. They are not machines that can do strenuous work and work long hours.

On the other hand, machines can do the job repeatedly without any complaint. These can detect skin, heart, eyes and other diseases. AI robots can do precision spinal cord surgery, too. AI is less invasive, faster and more accurate.

A recent report showed that an AI chatbot can diagnose medical conditions as accurately as a doctor. AI is also becoming more popular in areas such as radiology and cancer detection. All these new developments with AI raise the question: Will AI replace doctors and nurses in the future?

Co-founder of Sun Microsystems says that 80 per cent of doctors will be replaced by machines in the future. Some even think that bare hands may be banned and only AI robots will be allowed to do surgical procedures in the future.

AI replacing doctors in the near future is still a skeptical thought. A calculator can do amazing things at a fast speed and with accuracy, but that does not mean it can replace a mathematician. Doctors are required to develop medical AI.

Human emotion is the forte of human doctors. A company in Japan has developed emotional AI that can exhibit emotions. But patients need human touch, emotions and feelings. Human sympathy, empathy, perception and emotion are different from that of machines. So at this point of time, doctors are definitely going to stay!

What's next?

It is true that humans have a long record of failed quests for immortality. Can modern science and technology bring back the dead? Imagine a dead body kept in front of an AI machine. Now, let AI apply the most complex algorithm on the corpse. Lo and behold, the dead comes alive! Is that a possibility? No, that is creepy, and it can only be possible in imagination and in movies! AI cannot do wonders on the corpse, but it can revolutionise the medical industry in a big way.

Human organs and tissues can fail due to illnesses or accidents. Scientists can now repair damaged organs and tissues. There is a 3D bioprinting technique that prints human organs for replacing damaged organs. This means humans can now live longer.

AI has been created by humans—it is not a prophecy but a reality. And the reality is that we should expect the good, the bad and the ugly out of AI technology. There are speculations that a day will come when AI robots will effectively take control of the planet away from the human species. Such imaginations can cause fear and trepidation in humans.

It is certain that medical advances and AI could potentially lead to massive benefits in healthcare and medical diagnoses. There are lots of problems in the healthcare industry, such as human errors and staff shortages. AI can fill the blind spots and eventually solve problems that we are facing today.

There are always pros and cons of any new and emerging technology. One disadvantage with AI could be a concern for privacy/security for patients because data could be on the cloud or connected devices. There could also be bias towards people who cannot afford Internet connectivity and access to high-tech data resources. Since AI is based on algorithms, anyone who has bad intentions could also develop an algorithm. Bad government policies could impede productivity and harm humans. Without proper regulatory bodies, implementation of AI technologies could also be at risk.

Conclusion

AI has a lot of potential, enormous benefits and opportunities, and is sure to bring many wonders to the healthcare space. The emergence of medical AI could radically change the course of human history and the healthcare industry. AI and 3D printing could replace damaged organs just like replacing parts in machines.

AI technology is making its presence felt in the healthcare industry at a very fast pace. India is one of the fastest adopters of AI-based healthcare services. One of the greatest potential benefits of AI is to help humans stay healthy so that a doctor is not required as often. AI will not fully replace human doctors but will certainly improve physician

performance, and at the same time offer patients more accessibility to healthcare at lower costs. Proper regulations and a legal framework are required to make the best out of AI to serve mankind in a better and the most beneficial way.

CHAPTER 10

Artificial Intelligence On Hire!

Harness the power of popular artificial intelligence tools to transform your business operations and serve your customers better..



Artificial Intelligence On Hire!

By Paromik Chakraborty

Almost everyone agrees that artificial intelligence (AI) is the next big thing for businesses. But, is there any AI platform ready for you to deploy? While IBM's Watson is the most widely known AI platform, there are many more popular artificial intelligence tools for you to hire.

Almost everyone agrees that artificial intelligence (AI) is the next big thing for businesses. But, is there any AI platform ready for you to deploy? While IBM's Watson is the most widely known AI platform, there are many more popular artificial intelligence tools for you to hire.

Amazon AI

Amazon Web Services (AWS) offers a good range of AI services including tools, platforms, frameworks and infrastructure. Amazon Machine Learning is a cloud-based service that makes machine learning technology available to users of all skill levels. Using powerful algorithms, it helps users create machine learning models by finding patterns in existing data, and using these patterns to make predictions from new data as it becomes available. Offering a user-friendly interface utilising visualisation tools, wizards and more, the highly scalable platform enables creation, evaluation and deployment of meaningful machine learning (ML) models. AWS also provides AI services like image recognition, text-to-speech, voice and text chatbots, and more.

This service is widely used in applications like demand forecast, user activity prediction, item recommendation, fraud detection and suspicious transaction flagging, review filtering and so on. Amazon Machine Learning's secret of ease lies in its automated processing in every step.

Experts suggest that this platform is well-suited for users who are looking for quick and powerful yet low-cost solutions. It is also a recommendable platform for

relatively newer users. It can be used for retail, food chain, hospitality, sports and entertainment, and finance among other sectors.

Let's look at the example of Upserve—a US-based company that delivers cloud-based intelligence and management system for restaurants. Amazon Machine Learning, ingesting data like reservations, real-time payment processing, menu preference histories, customer count and so on, developed over a hundred machine learning models, which helped Upserve's client restaurants to improve profitability and drastically cut down on wastage based on major predictive parameters.

Google Cloud Machine Learning Engine

Google Cloud ML platform has made a mark very quickly despite being a much newer release than Amazon or Azure ML platforms. This platform attends to developers' desire of forging their own machine learning model—no matter how complex or how large. This ability comes from the TensorFlow system—Google's open source deep learning framework—lying at the heart of Google's machine learning platform.

The massively scalable machine learning engine backed by AI APIs for speech recognition, advanced search, natural language processing, video, image and text analysis, and much more, gives users a machine learning model with benefits like accurate real-time analytics, efficient anomaly detection and correction, prediction, easy search and recommendations, meaningful insight into complex unstructured data, automated processes and so on.

Customers of any stature ranging from search engines, online retail, job search sites, sales or marketing up to bioengineering or even aerospace and defence firms will find Google Cloud ML platform suitable for their requirement. The biggest confidence in using Google's offerings comes from the fact that the global giant itself uses the same technologies in its own systems as offered to its customers.

In a real-life scenario, Google's ML platform has benefited the likes of Airbus Defense and Space in detection and correction of satellite images. Even at high quality level, satellite images capture phenomena like cloud formation, which hinder the real motive of the picture like accurate atmosphere or seasonal analysis—something which is used in areas like precision farming, yield prediction or crop health analysis, where data is required to be absolutely precise. At Airbus, the process had been manual, time-consuming and error-prone for over a decade. Google's solution automated it and delivered to Airbus customers results with absolute accuracy and detailed insight. Thus, Google's platform is capable of delivering solutions for any scale of complexity.

IPSoft Amelia

USA-based IPSoft created an intriguing AI innovation, called Amelia. The interesting aspect of Amelia is its

interaction capabilities coupled with conversation and advanced learning talents that push it closer to the true sense of AI. Geared with advanced learning and self-learning tools, machine learning and deep learning capabilities, understanding of entire sentences and conversations with knowledge of 20 languages, and facial expression and emotion detection, the system can extract knowledge from large documents and historical records, interact directly with its employer's customers, educate human colleagues, oversee and streamline workflow in a management role, and do much more. The applications of Amelia put a major focus towards digital workforce management.

Chetan Dube, founder and CEO, IPSoft, says, "Amelia is neither a platform, nor a solution. It is a digital employee who has been designed with intelligence, reasoning and decision-making skills that help her more closely resemble the way humans think, act, and work. Amelia is a scalable digital workforce that can address as much work volume as needed. She has a direct impact on the key ROI metrics that shareholders and management teams prioritise above all others. Amelia's ability to learn more quickly, manage more complex dialogues, respond to analytical triggers in real time, and better understand those with whom she interacts with truly sets her apart as a valuable asset for any modern enterprise."

AI has the capability to take up any data-driven work, some examples being data mining, analysis, prediction, real-time actions and process automation, enabling decision-makers to efficiently manage their workforce by shifting repetitive or accuracy-major tasks to the platform. Currently, Amelia has been taken up by over 50 organisations globally in sectors as wide-ranging as financial services, telecommunications, leisure, travel, healthcare, IT, BPO and government. It is substantially involved in the roles of customer service, finance and banking, insurance, IT infrastructure management, human resources, service desks, or even technical guide or advisor for field-workers or engineers.

Let's take the case of an online gaming major which needed a sophisticated agent to connect with gamers for support and block phishing attempts or ever-evolving fraud techniques, for which the company needed to quickly adapt in order to maximise customer service and workflow efficiency. Amelia cannot be socially engineered—a feature the company leveraged to interact with human customers and verify accounts. Amelia is helping the gaming company to verify user identities at 100 per cent accuracy, cut fraud-screening time from five minutes down to three minutes and receive an 86.72 per cent customer satisfaction rating—higher than with human operators.

Microsoft Azure

Microsoft's machine learning platform was introduced for public preview in July 2014, and since then it has picked up good steam. The specialty of the Azure Machine Learning

platform is the interactive user interface brought by the integrated Azure Machine Learning Studio, which allows users to set up their machine learning model through simple drag-and-drop actions. Inbuilt algorithm makes building supervised and unsupervised learning models easy. However, the modelling process requires active intervention of users in all development steps. Support for R and Python programming languages is a bonus for users who plan to create or customise their own ML models.

Additionally, Azure ML supports a wide range of statistical functions and methods which are core to Data Science. Supported ML models include regression, binary and multi-class classification, clustering, recommendations and anomaly detection.

All user categories ranging from SMEs up to large industries in different verticals including retail, insurance, finance and banking, healthcare, oil and gas or even manufacturing can benefit from this AI platform. Smarter and swift predictive analytics, project outcome management, re-usable and scalable models, efficient data pipelines, risk and fraud management, and patient recovery and treatment prediction are some of the biggest benefits of Azure Machine Learning.

The Microsoft Azure website showcases a story where Mendeley, a free research content reference and academic network platform for researchers, students and academic readers, implemented Azure Machine Learning to manage its users better, provide more accurate recommendations, and improve interface response and overall user experience. Feeding historical data like user activity trends, views, libraries, searches and data provided by the marketing team, helped the company to build ML models, which eventually improved the company's recall by 30 per cent.

IBM Watson

IBM Watson is an interactive cognitive platform whose analytical basis is the humongous amount of disparate big data structures that the system can engulf. It computes this data at very high speed and analyses to give the results in minimal time.

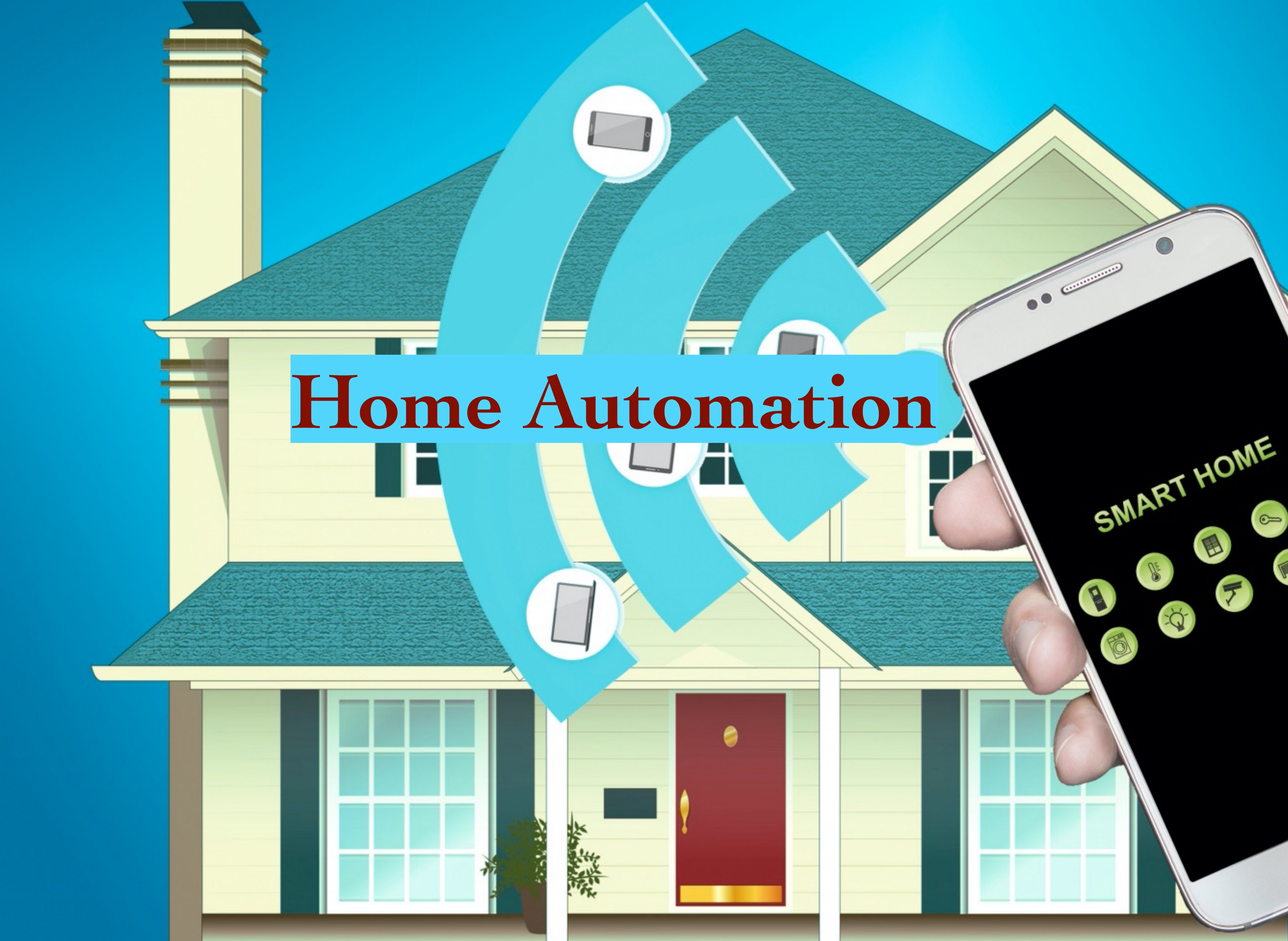
Talking about its cognitive and interactive capability, Dr Prashant Pradhan, executive director, Watson & Cloud, and chief developer advocate, IBM India/South Asia, says, "Watson understands the nuances of human language, so it is able to bring back relevant answers in context of the question. Watson also gets smarter, learning from each interaction with its users, and each piece of data it ingests."

Driven on the IBM Bluemix cloud platform, IBM Watson comes with 50 AI APIs including IBM dialogue, retrieve and rank, machine learning, speech-to-text, text-to-speech and, more interestingly, concept and visual Insight that enable an application to expand and relate concepts, drawing on the meaning of a word rather than simple text matching, and allow developers to build apps that reveal insights from social media images and video. As an analytics platform,

Watson provides a visual representation of the business drivers and insights into any focus areas. While the major involvement of the user is in loading the correct data, rest of the background computations are mostly automated within the system.

Watson has seen diverse uses in sectors like healthcare (to suggest treatments for cancer), financial services (to recommend personalised portfolios using the latest information), customer engagement, law, retail, fashion and education.

In an interesting application from India, Sriram Raghavan, director, India Research Labs, IBM India/South Asia, explains how Watson is being used in diverse industries like fashion as well. Designers at Falguni Shane Peacock took up IBM Watson to design their line called 'Future of Bollywood Fashion.' The system analysed data from 600,000 publicly available fashion runway images of the last decade, 5000 Bollywood celebrity images from social networks and 3000 historical Bollywood fashion images. With the help of visual recognition APIs and tools from the IBM Research Cognitive Fashion project, the system was able to assist significantly in the design process.


Home Automation
SMART HOME

CHAPTER 11

Home Automation Engineering: A Home With Eyes, Ears And Plenty Of Smarts

Security and monitoring in the field of home automation continue to evolve. New electronic designs and solutions continue to accelerate this trend. Now that many homes are automated, smart and connected, designers of electronics need to continue to offer improvements on issues related to power, sensing, command and control, and communications



Home Automation Engineering: A Home With Eyes, Ears And Plenty Of Smarts

By Paul Golata

My third daughter recently graduated from college with an art degree. I have had the opportunity to see her artwork displayed in areas made to resemble a museum. Besides the artwork on the wall, museums always make me think of security. If you are a fan of heist movies, you know that these always require that the thieves employ ingenious efforts to get in and snatch the priceless treasure. They must manoeuvre through all sorts of security, laser beams, motion detectors, pressure sensors and the like. How awesome would it be if our homes had the same technical advantages?

Home automation has evolved into the connected home, which is a broad system of home electronics that has so much intelligence it can quickly repay owners for upfront investment costs through efficiency savings and in a relatively short amount of time. The connected home promises to bring further automation into the home, linking together disparate technologies, appliances and devices, and coordinating them into a synergistic platform to serve homeowners, all within the control of their fingertips. As a simple and fully integrated system, home automation offers home occupants peace of mind, which in today's chaotic and turbulent world is of enormous economic value.

One aspect of home automation that helps drive peace of mind involves home security and monitoring. This article articulates how leading-edge innovation and electronic component technologies are supporting advanced smart home security and monitoring solutions. These advances stem from new developments in electronics, technology and design areas involving power, sensing, compute, command and control, and communications. Home automation is conveniently remaking the home environment, making it safer and more secure.

Security and monitoring

Consider for yourself a home automation system that could provide security and monitoring along with a wide variety of entertainment options. This home would incorporate infrastructure that can transmit and receive secure high-speed internal and external communication. It would do so in a manner that both optimises and minimises home resource consumption of utilities such as power, water, gas and

data. This automated home would have the intelligence to allow it to act as its own steward over low-end tasks within the home, operating in a manner analogous to a well-intentioned house sitter. This type of automated house would be both smart and connected.

Today's electronic components have become ever more affordable while simultaneously increasing exponentially in performance capabilities. Today's communication infrastructures and services have become wonderfully standardised, convenient and ubiquitous. Integration of both passive and active semiconductors to produce these complex infrastructures has brought forth a network so powerful that it equates to a personal, 24/7, around-the-clock, electronic butler in your home, on your property.

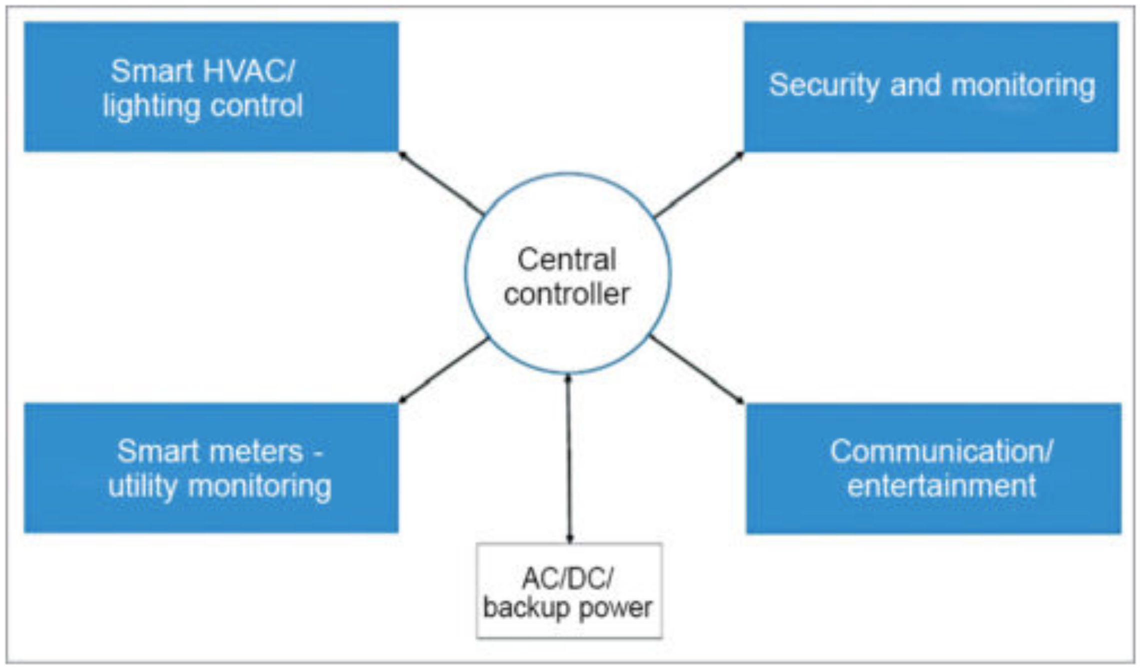


Fig. 1: Connected homes host a network of devices (Credit: AVX)

Automated homes consist of multiple separate systems that one integrates to work together. In its simplest form, one might envision an entire network as connecting in a manner as shown in the illustration in Fig. 1.

Since our focus is on security and monitoring, we will forego further discussion on the three other blue blocks in Fig. 1. Three areas that we will not discuss in this article are:

- Smart heating, ventilation and air-conditioning (HVAC), and smart lighting control
- Smart meters for utility monitoring
- Communication and entertainment

Before the development of the smart home, false alarms of intruder detection could account for up to 98 per cent of security triggers. This high level of false positives is expensive and ends up producing a syndrome analogous to the Aesop's Fables classic, The Boy Who Cried Wolf.

Smart sensors now have wireless capabilities, allowing for their optimal placement around the home. Many smart sensors have the requisite intelligence to ascertain what a true positive-alarm trigger condition is, thus avoiding false positives. Programming options through improved command and control products, like microprocessors, allow for custom tailoring of sensors, especially for such specifications as sensitivity and multiple confirmation triggers that assist with improving accuracy in identifying a legitimate alarm trigger.

Occupant health monitoring is an expanding area of development with the creation of powerful accelerometer monitors and motion/temperature sensors. Sensors have expanded to include monitoring water leaks, carbon-dioxide and carbon-monoxide buildup, and other volatile organic compounds (VOCs). Likewise, other important items that concentrate on the health and efficiency of systems such as HVAC performance relative to specifications undergo monitoring as well.

Power

Turning our attention to the four key technology-related design considerations of power, sensing, command and control, and communications, which enable home automation security and monitoring, we will start by examining how power management technology advancements are assisting in this effort.

Power management is a key design challenge in every Internet of Things (IoT) and home automation security product. The ability to answer high peak current demands and very lengthy, low-power system standby times requires solutions that extend battery life. Electronic components manufacturers focus on offering a wide variety of products in which electrical energy gets efficient utilisation and distribution where it is essential.

Non-isolated direct current to direct current (DC/DC) and point-of-load (POL) power supplies function in security and monitoring applications. On input side, power may come in via wired-power options, often through 12V DC or using a battery-powered option, with the possible inclusion of supercapacitors—a type of high-capacity capacitor—or often in the form of electric double-layer capacitors (EDLCs).

DC/DC power converters that adjust input voltage to what the system needs to output are often in operation. Designers working on such power converters may consider high-quality, synchronous buck converters, as these are compact and easy to use. These parts may provide ample efficiency advantages over low-dropout (LDO) regulators.

When home automation systems utilise battery-powered devices, often designers employ step-down converters. These parts assist with battery-based applications, as these are capable of drawing very low quiescent currents (IQs), guaranteeing that the parts will draw low currents from the battery when in a wait state.

Capacitors are key components for efficient power conversion. One common thread among high-efficiency switch-mode power supply, microprocessor and digital circuit applications is the need to reduce noise while operating at higher frequencies. Specifically valuable for filtering, tantalum capacitor technology has many of the ideal characteristics that DC/DC converters, power supplies and other applications require. In home automation applications, power supply capacitors should exhibit many of the following positive characteristics:

- High capacitance retention at high frequencies
- Low failure rate
- Wide voltage range
- Surge robustness
- Environment (moisture/temperature) resistance
- Low cost

Power designs require protection against transient voltages. Using a capacitor is a common technique to control transients and protect the circuit in voltage control designs. A capacitor may operate across the line/pin to integrate the voltage and assist in the prevention of electrostatic discharge (ESD) damage. Engineers often over-estimate the performance of a standard multilayer ceramic capacitor (MLCC) because of the capacitor's significant value drop upon an applied ESD event. Introduction of supercapacitors, in the place of MLCCs, will actually make a design more robust.

Sensing

Electronic systems allow security and monitoring systems to respond in changing situations, conditions and contexts. Sensors may signal door and window motions, smoke or carbon-monoxide presence, physical disturbances, pressure changes and more. These connected sensors offer a wide range of uses in smart home security and automation applications. Whether through specific sensor components and related op-amps employed to enable battery-powered wireless devices or through ESD protection for high-speed signal lines, engineers require a range of products to safeguard their designs.

Now, let us examine how sensor components and related solutions lead to excellent security monitoring design.

Sensor devices provide real-time system protection, feedback control and high accuracy system monitoring. Position sensors enable engineers to determine absolute and relative positions, including angle, presence, proximity, distance, flow, level and velocity. Such sensors as light, image and analogue front-end (AFE) help designers capture a broad range of wavelengths.

Because your human eyes cannot be everywhere, it is helpful to have another set of eyes on your home to establish extra protection. One option a designer might consider employing is an ambient light sensor. An ambient light sensor measures the intensity of visible light. Spectral response of the sensor tightly matches the photopic response of the human eye and includes significant infrared (IR) rejection (Fig. 2).

Still, looking for home intruders is not the only required sensing function in many security monitoring systems. Often a change in the ambient environment warrants monitoring. A change in humidity may indicate that an environmental shift is in process that may cause significant damage to valuables

within a monitored location. In such a situation, a humidity sensor may do the job. It can provide excellent measurement accuracy at very low power levels and may also include an integrated temperature sensor.In isolation, sensors alone may not be able to complete the job. Often, these need a signal boost using amplifiers so that downstream electronics can further manipulate and evaluate their electronic information.



Fig. 2: Automated security entry systems on the gatepost of a house offer an additional set of eyes for a homeowner's protection

Ultra-low-power, operational amplifiers find employment in sensing applications with battery-powered, wireless and low-power wired equipment. Such ultra-low-power, operational amplifiers help reduce power consumption in equipment like carbon-monoxide detectors, smoke detectors and passive infrared (PIR) motion detectors where operational battery-life is critical.

Command and control

At the core of any home automation security and monitoring application, there is a need to have command and control over electronic signals. A proper command and control system allows for the achievement of greater energy and operational efficiency in the system. By incorporating products and technology with the brains to better monitor and regulate systems, including lighting, windows and doors, video cameras and more, a home becomes more safe and secure for its occupants.

An effective way to utilise the command and control function is to use a controller, specifically a microcontroller unit (MCU). MCUs are useful in embedded devices, as these contain the processor, memory and peripherals in one integrated unit. Many of today's MCUs may excel at ultra-low-power sensing and measuring. These allow designers to use a command and control platform from which to coordinate their design requirements. Since they possess internal memory, both random access memory (RAM) and read-only memory (ROM), MCUs are well-positioned to deliver fast, flexible and reliable command and control functions without requiring additional off-chip capabilities.

Onboard memory and peripherals help MCUs minimise their total power consumption.

Communications

Home automation security and monitoring applications, of which the increasing need for wireless connectivity to accommodate the IoT is driving, require a new dimension of wireless connectivity security. Upon proper authorisation, only where appropriate, data must undergo proper protection by allowing proper send and receive transmissions.

In home automation security and monitoring designs, wireless MCUs, which fully support Bluetooth, Zigbee, low-power wireless personal-area networks (LoWPAN), Thread, Wi-Fi, sub-1GHz, Sigfox or other protocols must by design provide highly-secure, cloud-ready solutions for IoT accessibility. Additionally, wireless MCUs require an input voltage filtering/decoupling network and an output impedance matching network for the radio frequency (RF) antenna.

Today, wireless MCUs can offer designers access to distinct wireless protocol modes. These may offer a blend of long/robust range, low power and high data rates. By design, these often consume very low amounts of power, allowing for battery operation. These may come with sensors that help them recognise when these should be active and communicating, or when these should be in sleep or wait state.

Wireless MCUs give engineers greater flexibility, as the designers may consolidate the command and control function with communication function ultimately to offer high levels of integration. Such levels of integration will simplify designs and ensure continuously reliable communication.

Conclusion

Security and monitoring in the field of home automation continue to evolve. New electronic designs and solutions continue to accelerate this trend. Now that many homes are automated, smart and connected, electronic designers need to continue to offer improvements on issues related to power, sensing, command and control, and communications. A design engineer's imagination is never automated. Consider how your imagination may take hold of the future, and continue to make your future and your homes more convenient, secure and safe.

CHAPTER 12

Latest Wireless Technologies, Devices and Protocols for Secure Home Automation

A complete wireless networking is an indispensable element of home automation. In this article, we discuss the latest wireless technologies that are making our homes safer and more secure.



Latest Wireless Technologies, Devices and Protocols for Secure Home

By Deepshikha Shukla

Wireless technology for smart homes helps you keep an eye on your home when you are away. You can protect what is valuable to you at home or even manage your business remotely. It provides a safe, convenient and smart life through intelligent devices, cloud-based platforms and advanced technologies.

Innovative wireless technologies including 4G and 5G have paved the way for home automation. Now, you can enjoy home entertainment and remotely protect and take care of your family in a smarter and easier way. The Internet of Things (IoT) enables you to control your appliances, sharing videos or images captured by cameras to friends and families, turning on alarms and sensors, from anywhere. It allows your to do so by way of controlling programmable timing controllers, electrical appliances control systems and more via apps on your smartphone.

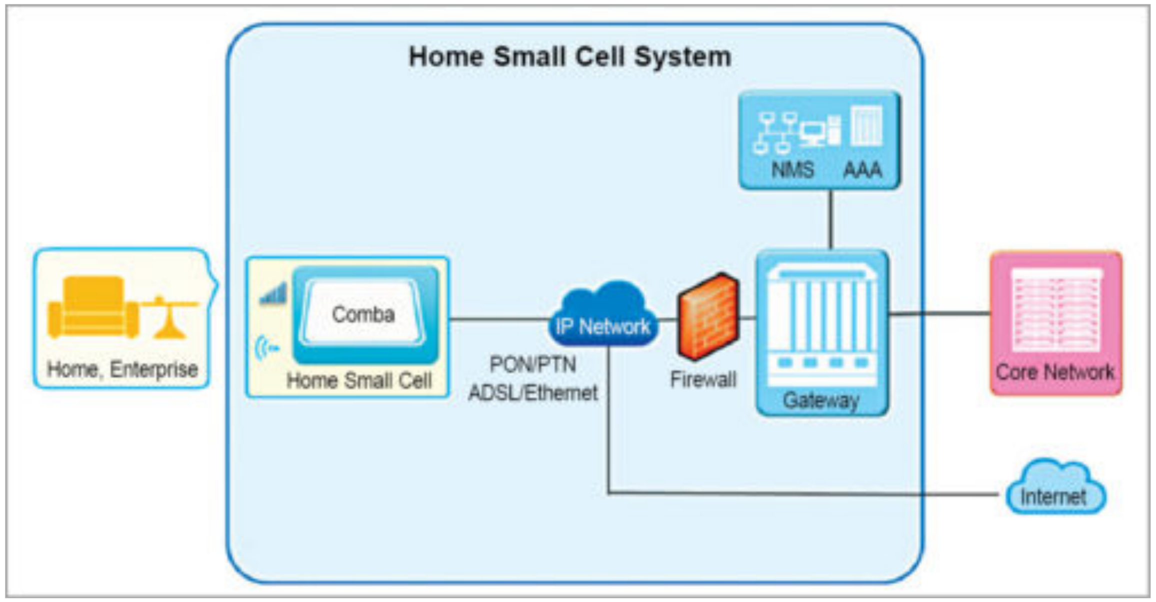
Latest technologies for better connectivity

LTE Small Cell technology provides complete, strong in-home wireless network coverage to support the implementation of home automation. It provides cellular indoor coverage via broadband IP backhaul. The technology can solve cellular network issues including weak coverage, low data rate and site acquisition. The solution increases the capacity for data service and offloads macro network by absorbing traffic from indoor hotspots. It gives quality connectivity and, hence, an excellent home automation experience for households.

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Dhananjay Sharma, chief operating officer, SenRa Tech Pvt Ltd, says, "LoRaWAN as a wireless technology is extensively used in home automation. The application ranges from door/window motion sensing, temperature sensing, carbon monoxide monitoring, water metering, gas metering and more. LoRaWAN gateways with integrated Wi-Fi are already available. This will further augment the use cases for high data rates as well as low data devices and battery-powered sensors."

Bluetooth Low Energy (BLE) is globally interoperable on 2.4GHz band, and is available on all smartphones and tablets. Recent standard evolutions with Bluetooth 5 as well as BLE Mesh make the technology even more suitable in a smart home. Bluetooth 5 gives double data throughput (2Mbps), which means that communication through an app is faster.

BLE also results in more power-efficient solutions. For example, a battery-driven sensor can send data much faster and then go to sleep, thus saving battery. Bluetooth 5 also increases coverage as the range between devices can be four times that of BLE 4.2, all due to the new BLE long-range coding scheme.

Stefan Berggren, senior product marketing manager – product strategy short range radio, u-blox, says, "Signals can now easily penetrate walls and obstacles in homes, thereby offering a more robust solution. Bluetooth 5 and BLE Mesh technologies are extensively used for making a home smart. Bluetooth Mesh extends coverage and robustness of a home automation system, as data is propagated via node-to-node hops in a mesh network.

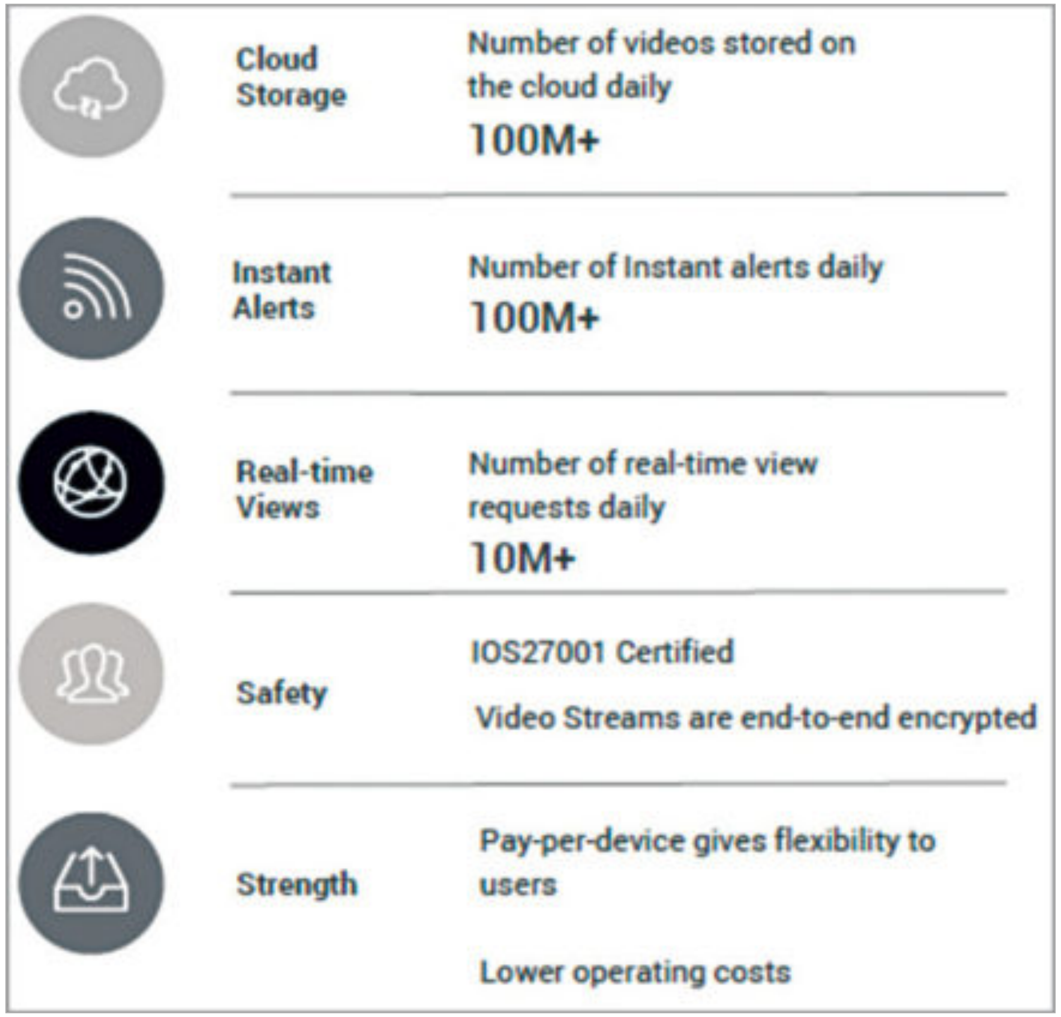
"Luminaires, light switches, sensors, thermostats, blinds and air-conditioners can all be connected in a mesh network. A smartphone can also be part of the Bluetooth Mesh network, and an app can easily control lighting and indoor climate systems.

"Solutions for other mesh technologies such as Thread, Zigbee and Wirepas Mesh are also applicable for home automation. Mesh networks in a smart home can be connected to the cloud via a capillary gateway, either using Wi-Fi/Ethernet through the home router or via cellular access."

Controlling devices wirelessly

Theodore Wang, marketing director – Latin America and India, EZVIZ (smart home security provider, and consumer and residentially focused subsidiary of Hikvision), says, "All smart home products can be connected to apps and cloud platforms. We utilise wireless technologies extensively in IoT-based home automation. Our smart home products, including smart locks, smart doorbells, smart plugs, gas detectors and wireless pet immune PIR detectors support IFTTT, Apple HomeKit, Google Home and Amazon Alexa. These can be connected to EZVIZ app and cloud platform.

"EZVIZ C6C Wi-Fi pan-tilt camera features smart tracking, which upon detection of movement automatically captures and tracks motion while delivering a notification, an image or a video to your smartphone via EZVIZ app in real time. A built-in microphone and speaker enable two-way audio, allowing you to communicate with people on the other side via the app. It also comes with a privacy mode design, allowing you to turn the lens off and enjoy some alone time."

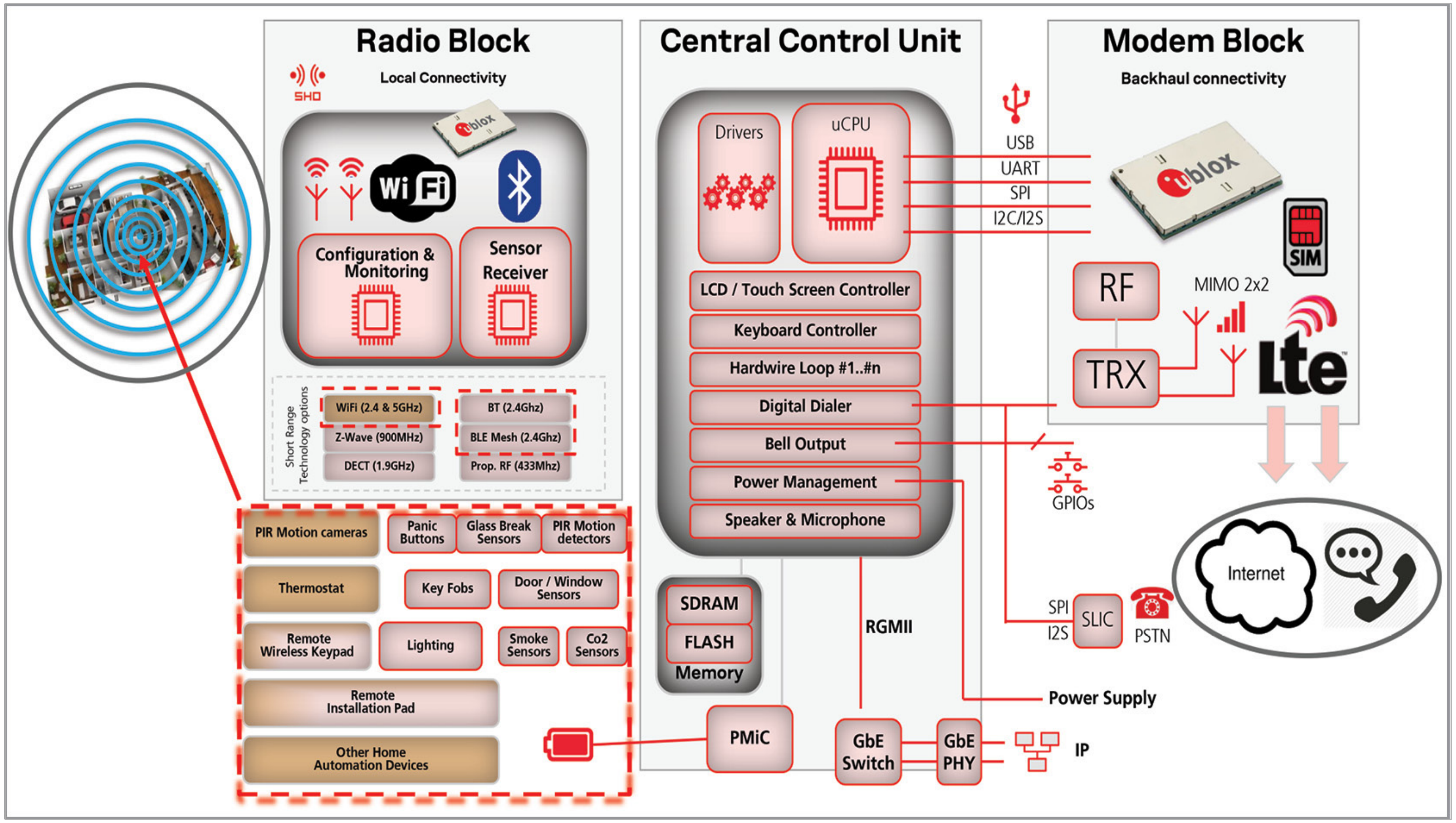


The company also creates wireless cameras that can deliver features like human detection, human tracking, face detection, face recognition, passenger flow monitoring and smart sound location.

A cellular module is generally present in 90 per cent of modern alarm panels. Depending on system architecture and

installation choice, cellular technology can be used as main communication access to alarm receiving centres and to the Internet, or as backup communication when paired with wired or Wi-Fi IP connectivity to the Internet.

Cellular communication is also used in other remote monitoring and alarm systems used in building automation, such as for access control, alert systems for elevators, smoke detectors and domestic healthcare monitoring applications, among others.

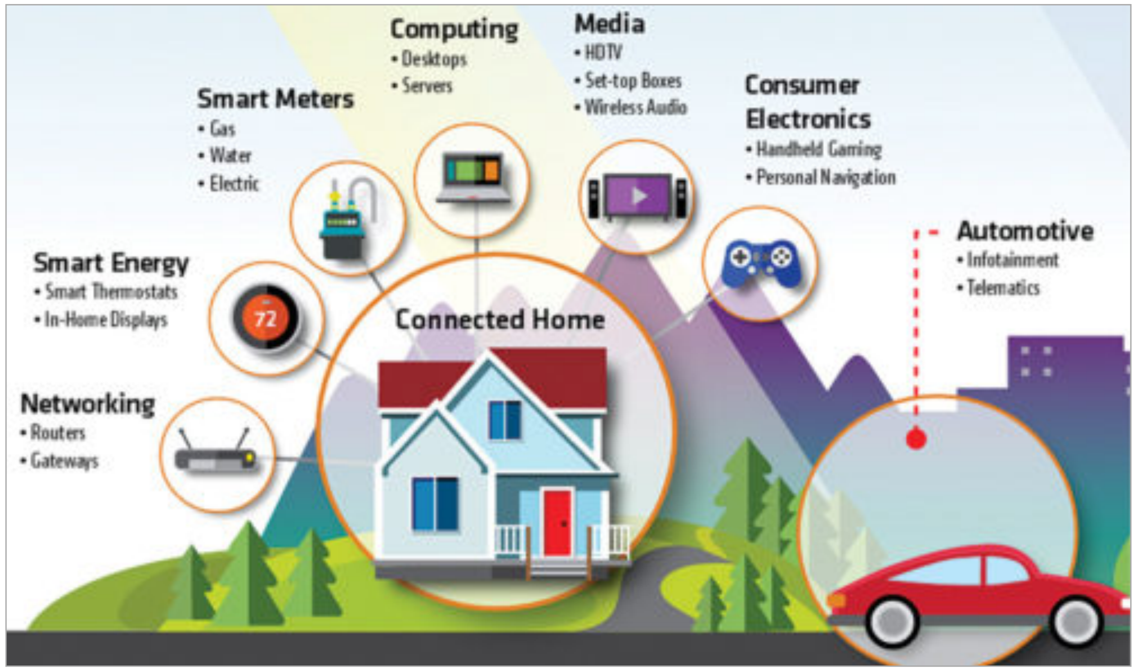


Diego Grassi, senior manager – product strategy, for cellular IoT market development, u-blox, says, “Cellular and low-power wide-area (LPWA) chipsets and modules are designed with a unique feature set in terms of security, anti-tampering and energy-efficiency. These address specific needs of IoT use cases including home automation applications.

“LTE Cat 1, Cat M1 and NB1 technologies with modules such as SARA-R4, SARA-N2 and LARA-R3 are now being used or designed in the most innovative home automation systems. Typical applications are residential and commercial security, building surveillance, alarm systems, home automation smart sensors, smoke detectors, actuators, access control and HVAC systems, domestic health monitoring and assisted living.”

John Hamilton, vice president – marketing, RFMW Ltd, says, “We support components designed into IoT devices through Skyworks’ SKY85309-11 front-end module. It is a part of the RF section of an IoT

radio. These products allow home-owners greater control over their home environment.



"A host of devices utilise Wi-Fi (IEEE 802.11), Zigbee 802.15.4 and Bluetooth products in smart thermostats, smoke and CO alarms, security system as well as routers, sensors, appliances and door locks, light switches, gaming consoles and televisions."

Protocols and security features for wireless technology

Comba LTE Small Cell solution follows IPSEC 3GPP TS 36 104 security standards and protocols. Whereas, LoRaWAN follows AES 128 security standards and protocols. EZVIZ applies the following security standards and protocols for secure control:

1. ISO/IEC 27001 certified information security
2. Bank-level encryption security
3. Encrypting videos and images using user-defined passwords
4. Double-encrypting data before saving to cloud servers
5. Disabled SSH, Telnet and Web Service
6. EZVIZ privacy protocols

Bluetooth Mesh networking is designed with security as its number one priority. It is essential that the software in a connected device is not tampered with. Secure Boot feature provides surety that the firmware is authentic, has not been modified and cannot be downgraded.

u-blox security features are given below.

1. 3GPP standardised end-to-end security
2. Full two-way manageable channel
3. Security based on end-to-end 3GPP encryption
4. Data from device to cloud remains unchanged
5. Guaranteed quality of service (immunity to interference)
6. Device interoperability enabled by open standard protocols
7. Facilitate operations with horizontal IoT platforms

8. Embedded anti-tampering, lifetime security services
9. Integrated secure element

There are many technology platforms and protocols for building a smart home. A smart home protocol must support a large number of devices, as well as offer the best possible device interoperability. Other factors are power consumption, bandwidth and, of course, cost.

Future scope of wireless technologies

The IoT connects things together through the cloud. Home automation is impossible if applications and systems are unable to connect with the network. A complete wireless network is an indispensable element of home automation. Thus, scope of home automation is not only about technologies for the applications, but also technologies for the networking system.

Enhancements in Mesh technologies improve performance and capacity. We are seeing an evolution of end-to-end security in constrained networks. Artificial intelligence (AI) used for human behaviours and patterns monitoring will result in an exponential growth of cellular and short-range technologies in the ecosystem of home automation.

CHAPTER 13

Role of IoT in Home Automation

Today in the headway of Automation innovation, life is getting simpler and less demanding in all spheres. Home automation is a modern technology that modifies your home to perform different sets of task automatically.



Section 1

Role of IoT In Home Automation

By Ashish Gulati

Today Automatic frameworks are being favoured over manual frameworks. No wonders, home automation in India is already the buzz word, especially as the wave of second generation home owners grows, they want more than shelter, water, and electricity.

The first and most obvious advantage of Smart Homes is comfort and convenience, as more gadgets can deal with more operations (lighting, temperature, and so on) which in turn frees up the resident to perform other tasks. Smart homes filled with connected products are loaded with possibilities to make our lives easier, more convenient, and more comfortable. There is no shortage of possibilities for smart home IoT devices as home automation seems to be the wave of the future. The requirement for Office and Home automation arises due to the advent of IoT, in a big way in homes and office space. The smart home/office gadgets interact, seamlessly and securely; control, monitor and improve accessibility, from anywhere across the globe. These smart automation devices happen to have an interface with IoT. IT automation will be the key to bridging the gap between human limitations and technology's capabilities. With automation, data can be instantly collected and seamlessly passed between devices as it's simultaneously analyzed. Home automation is an appealing context for the Internet of Things (IoT), by connecting the IP gateway directly to the Internet or through a home/residential gateway; this system can be managed remotely using a PC, Smart phone, Tablet or other devices

The IoT based Home Automation will enable the user to use a Home Automation System based on Internet of Things (IoT). The modern homes are automated through the internet and the home appliances are controlled. The user commands over the internet will be obtained by the Wi-Fi modems. The Microcontroller has an interface with this modem. The system status is displayed through the LCD display, along with the system data. This is a typical IoT based Home Automation

system, for controlling all your home appliances. The smart home market is taking off as IoT device prices come down and the general public comes to understand the benefits of these products. And from smart homes, the next logical step is smart cities, which would take the IoT to the next level. And yet, smart homes are just one small part of our daily lives that the Internet of Things will transform in the coming years.

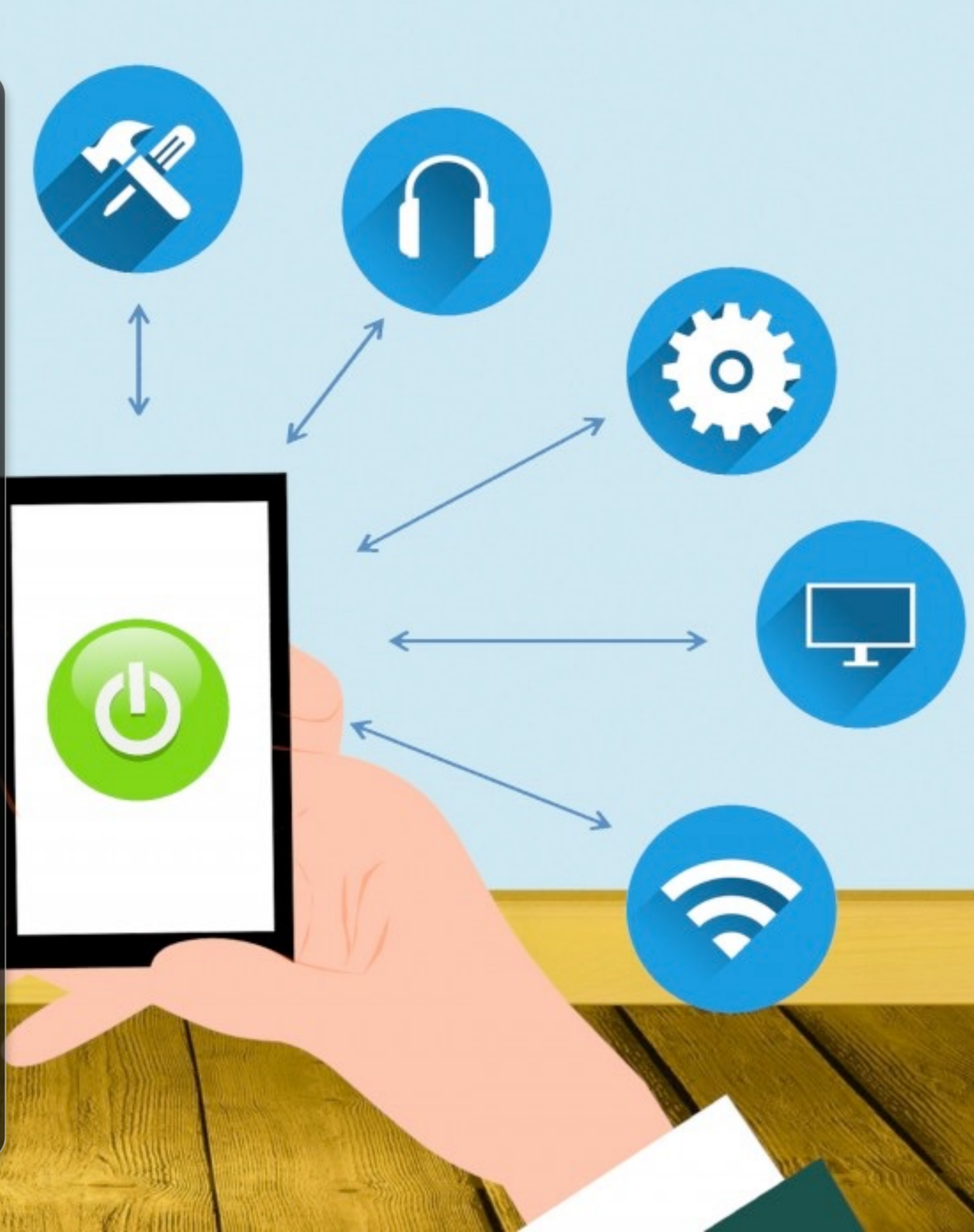
We have already witnessed some early commercial success in the IoT industry where today, everyone is talking about Internet of Things which is the "next big" thing in the world of technology. The prospect of 30 billion objects connected to the Internet by the year 2020 is staggering, as the opportunities for new lines of service and new business models grow out of this realm. IoT is based on the inclusion of devices in the world of connected environments. The devices are embedded and connected, based on a unique identity. The IoT devices in Home Automation have the maximum applications in energy. The home heating devices are able to control the temperature with the devices like laptops, tablets or smart phones and all of these appliances, systems, and devices contain sensors that connect them to a network. This is where IoT comes into place, and makes it such an integral part of the home automation. With the help of IoT technology, you can control devices as and when you want.

The beauty of the Home Automation system lies in the fact that the settings are manageable from your smart phones and other remote-control devices. Smart home IoT devices can help reduce costs and conserve energy. The Home Automation segment includes smart lighting, smart TVs and other appliances. Wearable's (Smart Watch, fitness brands, smart headphones, smart clothing) are also expected to witness the growth in the future. IoT is really the secret that makes this whole system work. Today in India, nearly 22.5 per cent of the consumers surveyed were familiar with the concept of IoT, with maximum awareness seen in the 36-55 age group which clearly indicates that there is immense opportunity for increased adoption of such technologies. The future of the Home automation market will happen with few key upgradations in the Automation technology. For example, Wireless Automation solutions as well as lowering of price points as the market begins to accept Home automation usage in larger volumes. With an increased internet penetration and data usage, the connected devices segment is expected to witness a huge growth by 2020. Home Automation in India is creating big opportunities, not only for Indian automation companies, but also for foreign companies. The rapid development of home-based automations, along with M2M (machine-to-machine) communications will continue to create billions of new connected objects over the next 5 years and beyond.

CHAPTER 14

Open Source Automation Tools to Make Your Home Smart

In a smart home, controlled objects are typically connected to a hub, which may be a wall-mounted unit, a tablet or even a smartphone. This article lists nine open source home automation tools you can choose from to make your home smart.



Open Source Automation Tools to Make Your Home Smart

By Vinayak Ramachandra

Automating your home has become a rather complex task with the ever expanding number of devices available to automatically protect and monitor your home. There are many open source devices to control window shutters, doors, fans, lights, air-conditioners, microwave ovens, etc in the market. On one hand, you may want to protect your home from theft, fire or other threats, while on the other, you may be interested in reducing your energy usage, for which there are countless devices available. Home automation can include scheduling and automatic operation of lighting, heating, air-conditioning, window shutters, security systems and more.

The many possibilities in home automation enable you to build wireless networks, automate all consumer electronic devices at home, monitor pets when you are away, set up an answering system, create a weather station and more. All of this involves integrating many different home automation technologies into one.

A home automation system works on its own protocols, which are specific to the company that developed the system. Software companies may favour such an approach as it ties customers to only their products. It is therefore important to evaluate a home automation system to ensure that it is built on open protocols. Such open solutions are released under an open source licence.

Home automation may also allow vital home functions to be controlled remotely from anywhere in the world, using any device with a browser that has an Internet connection.

A smart home is a wonderful thing. It learns your habits, watches out for intruders and even sends you alerts when things do not go according to plan. And it communicates with you remotely.

Trustworthy and powerful communication protocols like Z-wave or Zigbee still work with open source systems. Hubs that work with open source smart home software are competitively priced, and are perhaps even cheaper in the long run because one can optimise home systems more easily with these.

Nine open source solutions available in the market, with their main features, are given below.

Home Assistant

This open source home automation platform was developed with software written in Python. It works asynchronously and has very low requirements in terms of specifications. It can control a home's lights and window blinds using a programmable logic controller connected to a home assistant using MQTT protocol. It can receive information from several sensors using a radio frequency (RF) gateway. It can also be connected to IP cameras to retrieve motion sensing events and send notifications through various services.

openHab

This home automation platform aims for integration and interaction between different home technologies and devices.

Main features are:

- Vendor- and technology-agnostic
- Developed in Java
- Runs on any device capable of running Java Virtual Machine (JVM)
- Integrates different home automation technologies into one
- Comes with different Web-based user interfaces (UIs)
- Provides APIs for being integrated with other systems

MyController

This home automation server allows monitoring and control of the home from anywhere.
Main features are:

- Lightweight server
- Supports Linux, Windows and Raspberry Pi
- Supports multiple gateways with many protocols (serial, Ethernet and MQTT)
- Time-based operations
- Gives notifications, alarms and graphical reports
- Comes with interactive dashboards

Domoticz

This is a lightweight home automation system that allows monitoring and configuration of lights, switches, sensors and other devices. It also allows you to send notifications and alerts to any mobile device.

Main features are:

- Compatible with all browsers
- Works on several operating systems with a scalable HTML 5 Web front-end that adapts to desktop and mobile devices
- Runs on Raspberry Pi, Cubie board, UNIX, Apple and Windows

Fhem

This is a Perl server for home automation, released under GPL licence. It automates tasks like switching on lamps, window shutters, heating and so on. It also logs stats like temperature, humidity and power consumption.

Main features are:

- Runs as a server
- Controls devices via Web or smartphone front-end, and via Telnet or TCP/IP directly
- Supports several protocols
- Auto creates a device's logs when receiving data from a new device
- Logs events to files or database
- Sends notifications about external programs or scripts when it receives data about certain events
- Timed commands
- Several interfaces: Simple text, JSON, XML, etc

Major DoMo

This is an open source home automation platform designed to be used in a multi-protocol and multi-services environment.

Main features are:

- Can be installed on almost any computer running Windows or Linux
- Easy installation
- Supports many protocols (MQTT, Zwave, I-wave, I-wore, ModBus, SNMP, Ethernet)
- Offers Web-based interfaces for any device
- GPS tracking
- Scripting with PHP and/or Blockly
- Sets up automation rules and scripts

Pytomation

This is a lightweight open source automation system written in Python. The software can be used for home automation and lighting control, though it is not limited to these uses alone. It can work on any platform that supports Python (Windows, Mac OS X, Linux, etc).

Main features are:

- Executes actions based on voice inputs, time of day, file data, serial port data and socket data, as well as serial and speech protocols
- REST API
- Mobile Web and Android clients with continuous device updates (Web sockets)

- Voice commands from Android (Home Control app)
- Local Telnet and Web access
- Has a unique language to describe devices and actions
- Works with smart objects like doors, lights, motion sensors and photo cells
- Optional Mini loop programming for complicated controls
- Easy to add new hardware drivers
- Good communication, complete with examples
- Maps one command to another with source and time
- Optional event-driven programming for complex actions when the device state changes

Freedomotic

This open source, flexible, secure Internet of Things (IoT) development framework is useful to build and manage modern smart spaces. It is integrated with popular building automation technologies like BTicino Open Web Net, KNX Modbus RTU and X10, as well as with custom automation projects using Arduino devices, DIY boards, third-party Android front-ends, text-to-speech engines, motion-detection sensors using IP cameras, social network integration like Twitter and much more.

Freedomotic complies with well-known standards and building automation protocols as well as with DIY solutions. It treats the Web, social networks and branded front-ends as first-class components of the system. It can run on Raspberry Pi.

Main features are:

- Written in Java; can run on Windows, Linux, Mac and Solaris
- Can be deployed on a network of cheap peer-to-peer hardware nodes; is scalable and can be used in small apartments as well as large buildings
- Modular: Uses plugins and cross-language APIs, which are distributed along with the software to easily create new add-ons
- Connects to different software, hardware, front-ends and services apps developed in your preferred programming language using REST, STOMP or plain Java
- Runs many front-ends at the same time, even from a remote control
- Has abstraction layer for hardware infrastructure (sensors and actuators)
- Event based: Every action in real environment and every interaction with the system mapped to an event
- Semantic (logic)-rich: Provides semantic-rich knowledge of environment topology, people and objects to implement intelligence and reasoning methods

No coding required; environment can be described using graphical editors

- History aware: Records environment changes in a separate and dedicated database; historical series can be queried to provide charts, reports, alerts or used to create history-aware intelligent automations
- Available in more than 20 languages

Pi Dome

This home automation platform has been exclusively developed for Raspberry Pi. It provides solutions for end users as well as developers and hobbyists. Besides being a server, it also includes clients for multiple platforms.

Main features are:

- Suitable for technical and non-technical users
- Runs multiple commands at the same time
- Has a dashboard for all client types
- MQTT broker with client functionalities
- Plugins for utility measurements, universal remote controls, SMSs, media (XBMC) and weather data
- Automatic creation of data graphs
- Allows you to write your own client with Java client libraries

Open source does offer a wide selection of automation solutions to help you make your home smart. You can research on this basic information and choose the solution you feel will work best for you.

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